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## Aims and Scope

The Journal of Trauma and Injury (J Trauma Inj, JTI) is an official publication of the Korean Society of Traumatology and an international, peer-reviewed open access journal.

This journal aims to contribute to saving lives of patients who underwent traumatic events through active communication and exchange of study information on trauma and provision of education and training on trauma. Thus, the journal publishes original basic and clinical research on trauma-associated medical fields, such as surgeries (which include general surgery, chest surgery, orthopedic surgery, neurosurgery, plastic surgery, and head and neck surgery), gynecology and ophthalmology, emergency medicine, anesthesiology, neuro-psychiatrics, rehabilitation medicine, and radiology (which include interventional radiology). Due to the special circumstances Korea is under with North Korea, JTI also publishes basic and clinical research on battlefield trauma unique in Korea and has established ties with the Armed Forces Medical Command and Armed Forces Capital Hospital. Furthermore, this journal includes all items closely associated with medicine, disaster and department of emergency, emergency medical technicians and nurses, social infrastructures and systems, and government policies and supports.

JTI was launched in June 1988 with publications in the Korean and English languages and was eventually converted to an English-only journal. The journal publishes original articles, case reports/case series, review articles, editorials, correspondence, and articles commissioned by the Editorial Board, related to basic or clinical research on trauma.

## Open Access



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# Evolution of trauma care and the trauma registry in the West Australian health system

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Trauma care is evolving throughout the world to meet the demand resulting from rapidly increasing rates of mortality and morbidity related to external injuries. The State Major Trauma Service was designated to Royal Perth Hospital in 2004 to provide comprehensive care for trauma patients in Western Australia (WA), which is the largest state by area in the country. The State Major Trauma Unit, which was established in 2008, functions as a level I center and admits over 1,000 major trauma patients per year, making it the second busiest trauma center in Australia. The importance of recording data related to trauma was identified by the trauma service in WA to inspire higher standards of patient care and injury prevention. In 1994, the service established a trauma registry, which has undergone significant changes over the last two decades. The current State Trauma Registry is linked to a statewide database called the Data Linkage System. The linked data are available for policy development, quality assurance, and research. This article discusses the evolution of the trauma service and the registry database in the WA health system. The State Trauma Registry has enormous potential to contribute to research and quality improvement studies along with its ability to link with other databases.

**Keywords:** Trauma centers; Registries; Database; Morbidity; Mortality

## INTRODUCTION

Trauma is defined as single or multiple injuries that are life-threatening or life-changing in terms of long-term outcomes and related disabilities. These injuries result from external forces such as motor vehicle crashes, interpersonal violence, falls, gunshot wounds, and industrial injuries [1]. Trauma centers are established in all mature health care systems to provide thorough evaluations and care to acute trauma patients. The American College of Surgeons (ACS) defined a ranking order for trauma centers depending on the number of patients admitted annually and the availability of surgical and medical specialties, nursing, radiology, critical care, anesthetic services, and other resources. The ACS defined several levels of trauma care, such as level I (comprehensive services) and level III (limited services) [2,3].

Western Australia (WA) is the largest state in Australia and has a widely dispersed population, leading to significant challenges in delivering health services. It consists of three main metropolitan area health services and a country health service. The State Major Trauma Unit (SMTU) is located in Royal Perth Hospital, Perth,

WA, Australia. The SMTU functions as a level I trauma service, providing comprehensive care for major trauma across the state. About 6,000 patients are treated through the service annually, with access to all specialty services as described by the Royal Australasian College of Surgeons [4].

The State Major Trauma Service collects data for all trauma patients admitted to the hospital, as well as to other centers in the state, and maintains the State Trauma Registry (STR) database. Those who present to a health care service more than 7 days following a trauma event or stay in the health service for less than 24 hours are not included in the registry. The STR has undergone significant changes since its establishment 26 years ago. The aim of this review is to examine the trauma service in WA and the current trauma registry data collection system.

## EVOLUTION OF THE TRAUMA SERVICE IN WA

Major trauma care was provided by the major hospitals in WA for over 100 years. Emergency departments increasingly played leading roles in managing trauma patients with surgical and other specialty support over the last 30 years. However, population growth, with the increased volume and complexity of major trauma and the availability of modern trauma management strategies, called for the consolidation of comprehensive trauma care. The need for a mature trauma system in WA was initially identified and designated by the WA Department of Health in 2004. The Trauma Working Group was formed and subsequently a plan was developed in 2008 to establish a WA Trauma Care System [5].

The SMTU is a 30-bed, specialized unit dedicated to the care of complex and multisystem trauma patients. The medical model of the unit consists of four trauma surgeons, five registrars, five resident medical officers, and two interns. The trauma unit manages all acute multisystem major trauma patients in the state and admits over 1,000 major trauma patients (Injury Severity Score >12) per year, making it the second busiest trauma center in Australia. However, some trauma patients may be admitted to other health services within the state. Those patients in other facilities meeting the trauma team activation criteria (based on mechanism, physiology, and suspected injuries) are transferred to the STMU through a standardized major trauma interhospital transfer protocol. Once trauma patients are stabilized and acute injuries have been dealt with, patients are then referred to the most relevant specialty for longitudinal care. This transitional concept of the SMTU allows for the consolidation of complex, multitrauma patients into a single, dedicated area that facilitates improved coordination among multiple specialties in the management of the acute phase of the patient journey. Dedicated high-acuity beds allow earlier step-down from the intensive care unit and a higher level of care for complex trauma patients than that available on a general ward. More recently, the SMTU became the first pilot ward for the Health in a Virtual Environment remote monitoring service, further enhancing the critical care capabilities of the unit. Elderly patients with complex comorbidities receive comprehensive geriatric assessment through the perioperative geriatric services to improve their outcomes. Coordination and active involvement of other surgical and medical specialties are encouraged for trauma patients in the SMTU.

## THE STATE TRAUMA REGISTRY IN WA

The function and effectiveness of trauma care in WA are monitored through a trauma registry database, which was initially established in 1994 by Royal Perth Hospital. Later, other metropolitan health services started collecting data on trauma patients (Table 1).

The STR database commenced combining all trauma data into a single database in 2011. The STR coordinates data collection and evaluation of trauma demographics and hospital care for the purpose of monitoring the function and effectiveness of the WA trauma system. The main objective of the STR is to inspire higher standards of patient care and injury prevention. The registry monitors injuries, categorizes them, measures outcomes after injury, identifies system requirements, and reports and audits for quality improvement.

Almost all major trauma patients are transferred to the STMU according to the transfer protocol (stated above). Admission to STR is based on hospital admission, and only those whose length of stay is more than 24 hours in a registry hospital are entered to the registry. Those WA trauma patients who do not reach the Perth metropolitan area for admission to a registry hospital are also not captured (Table 1). Hospital Morbidity Data Collection is a registry that includes all hospitalized patients (Table 2). An automated data collection process of the Hospital Morbidity Data Collection minimum dataset was implemented in order to capture all WA trauma admissions throughout the state that meet the trauma registry criteria. This process started in January 2021, and all statewide trauma patients are recorded in the STR. Patients with major trauma, regardless of whether they are alive or deceased, who are identified by this process, will be manually captured using electronic information systems by the STR research nurses.


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**Table 1.** Health services that have joined the Trauma Registry of Western Australia

| Health service | Major trauma (ISS >15) | Minor trauma (ISS <16) |
|---|---|---|
| Royal Perth Hospital | From Aug 1994 | From Aug 1994 |
| Perth Children's Hospital[a)] | From Aug 1998 | From Aug 1998 |
| Fremantle Hospital | From Jan 1997 to Dec 2014 | From Jan 2012 to Dec 2013 |
| Joondalup Health Campus | From Jan 2010 | From Jan 2010 |
| Sir Charles Gairdner Hospital | From Jan 1997 | From Jan 2012 |
| Fiona Stanley Hospital | From Feb 2015 | From Feb 2015 |
| St John of God Midland Hospital | From Jan 2018 | From Jan 2018 |

ISS, Injury Severity Score.
[a)]Formally Princess Margaret Hospital of Children.

**Table 2.** Health registries linked to the Western Australia Data Linkage System

| Registry name | Available since |
|---|---|
| Birth Registrations | 1945 |
| Cancer Registry | 1982 |
| Death Registrations | 1969 |
| Emergency Department Data Collection | 2002 |
| Electoral Roll | 1988 |
| Hospital Morbidity Data Collection | 1970 |
| Mental Health Information System | 1966 |
| Midwives Notification System | 1980 |
| Mortality Data: Coded fields | 1969 |
| Western Australian Notifiable Infectious Diseases Data | 1988 |
| Western Australian Register of Developmental Anomalies | 1980 |
| Home and Community Care | 2004 |
| Aged Care Assessment Program | 2003 |
| Western Australian Trauma Registry | 1994 |

There are additional health-related and other government datasets.

A detailed dataset is collected on major trauma patients (Injury Severity Score >12), from the time of trauma to discharge from hospital. A limited dataset is collected on minor trauma admissions (Injury Severity Score <13). Previously, the trauma registries collected data individually in separate, although identical, Microsoft Access databases (Microsoft Corp., Redmond, WA, USA). Research nurses (Australian Nursing Federation level 2) and other officers collected trauma data, collaborated, and maintained the consistency and validity of the WA trauma registry [6]. The inter-registry staff were combined informally to ensure that data was consistently collected, in terms of data elements and interpretation, across all sites. In 2006, Royal Perth Hospital developed a web-based structured query language trauma registry database, which allows direct interface with hospital information systems (Patient Administration System, Emergency Department Information System, Theatre Management System), making it possible to merge verified data such as demographics and surgical procedures. The new database provides augmented data quality via the use of improved validation rules and mandatory fields. In January 2011, the WA Department of Health and Health Information Network rolled out this database to the other WA hospital registries to facilitate the development of the WA STR database. The migration of legacy data has yet to occur, pending information technology resources; therefore, data for some registries are contained across two databases, as shown in Table 3.

The STR is a useful resource for research and quality improvement projects. STR data have been used to help guide national injury prevention policy by Public Health Association of Australia [7]. One study based on STR data found that the risk of death after major trauma was twofold higher in rural WA, but if patients survived transfer to the SMTU, the outcomes were equivalent to metropolitan areas. The trauma transfer policy was subsequently altered such that all major trauma patients are now transferred directly to the STMU [8]. Another study conducted recently, through collaboration with 31 trauma centers across Australia and New Zealand, described demographic and clinical variables predicting trauma mortality and length of stay. These variables are now used to assist in benchmarking the clinical outcomes of different trauma centers [9]. Another study found that there was a 6.1% risk of missing cervical spine injuries on plain radiographs, predominantly in older people. This resulted in the routine use of computed tomography cervical scans for all people over the age of 65 years with cervical spine injuries [10].

At the same time, the STR is routinely linked to the WA Data Linkage System (WADLS). The WADLS initially commenced as a collaboration between the Department of Health WA, University of WA, Curtin University, and Telethon Kids Institute in 1995 [11]. Later it was brought into the Department of Health WA,

**Table 3.** Trauma registry databases

| Registry | Pre-January 2011 | Post-January 2011 |
|---|---|---|
| Royal Perth Hospital | New SQL database | New SQL database |
| Princess Margaret Hospital for Children | Access database[a)] | New SQL database (from Jan 2010) |
| Fremantle Hospital | Access database | New SQL database (until Dec 2014) |
| Joondalup Health Campus | New SQL database | New SQL database |
| Sir Charles Gairdner Hospital | Access database | New SQL database |
| Fiona Stanley Hospital | Not applicable | New SQL database |
| St John of God Midland Hospital | Not applicable | New SQL database |

SQL, structured query language.
[a)]Microsoft Access (Microsoft Corp., Redmond, WA, USA).

where it continues to operate. The WADLS connects information from multiple databases related to West Australians using personal identifying data, with the associated health or service data held separately. The linked data can be requested for policy development, quality assurance, and research [12]. More than 40 registries, including the STR, are linked via the WADLS. Major registries from the Department of Health are listed in Table 2, and additional health-related and other government datasets are managed by the service. By 2008, the WADLS had already supported more than 400 research studies, over 250 publications, and about 35 research degrees [13].

## CONCLUSION

Major trauma care in WA is led by the State Major Trauma Service, which provides trauma care in the largest state in Australia. The State Major Trauma Service is a mature trauma service (ACS level I), delivering the best available trauma care, in collaboration with multiple health institutions across the state. The STR collects and combines trauma-related data, which are linked as part of the WADLS infrastructure to enable further analysis and storage. This review identified the potential of the trauma database and linkage services as sources of information that can be used to improve the outcomes of major trauma patients in WA.

## NOTES

### Ethical statements
Not applicable.

### Conflicts of interest
The authors have no conflicts of interest to declare.

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### Author contributions
Conceptualization: MTI; Data curation: MTI; Formal analysis: LF; Methodology: MB; Project administration: SR; Writing–original draft: MTI; Writing–review & editing: MB, SR, LF.
All authors read and approved the final manuscript.

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Original Article

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# Clinical implications of the newly defined concept of ventilator-associated events in trauma patients

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**Purpose:** Ventilator-associated pneumonia is the most common nosocomial infection in patients with mechanical ventilation. In 2013, the new concept of ventilator-associated events (VAEs) replaced the traditional concept of ventilator-associated pneumonia. We analyzed risk factors for VAE occurrence and in-hospital mortality in trauma patients who received mechanical ventilatory support.

**Methods:** In this retrospective review, the study population comprised patients admitted to the Jeju Regional Trauma Center from January 2020 to January 2021. Data on demographics, injury characteristics, and clinical findings were collected from medical records. The subjects were categorized into VAE and no-VAE groups according to the Centers for Disease Control and Prevention/National Healthcare Safety Network VAE criteria. We identified risk factors for VAE occurrence and in-hospital mortality.

**Results:** Among 491 trauma patients admitted to the trauma center, 73 patients who received ventilator care were analyzed. Patients with a chest Abbreviated Injury Scale (AIS) score ≥3 had a 4.7-fold higher VAE rate (odds ratio [OR], 4.73; 95% confidence interval [CI], 1.46–17.9), and those with a glomerular filtration rate (GFR) <75 mL/min/1.73 $m^2$ had 4.1-fold higher odds of VAE occurrence (OR, 4.15; 95% CI, 1.32–14.1) and a nearly 4.2-fold higher risk for in-hospital mortality (OR, 4.19; 95% CI, 1.30–14.3). The median VAE-free duration of patients with chest AIS ≥3 was significantly shorter than that of patients with chest AIS <3 (P=0.013).

**Conclusions:** Trauma patients with chest AIS ≥3 or GFR <75 mL/min/1.73 $m^2$ on admission should be intensively monitored to detect at-risk patients for VAEs and modify the care plan accordingly. VAEs should be closely monitored to identify infections early and to achieve desirable results. We should also actively consider modalities to shorten mechanical ventilation in patients with chest AIS ≥3 to reduce VAE occurrence.

**Keywords:** Trauma centers; Pneumonia; Hospital mortality; Ventilator-associated pneumonia

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## INTRODUCTION

Ventilator-associated pneumonia (VAP) is the most common nosocomial infection in patients requiring endotracheal tubes with mechanical ventilation [1]. The reported prevalence of VAP in trauma patients is about 4-fold higher than that in non-trauma patients [2]. Before 2013, the Centers for Disease Control and Prevention (CDC), the American Thoracic Society, and the Infectious Diseases Society of America collaborated to provide the surveillance definition of VAP [3–6]. However, over time, many concerns were raised about the effectiveness, reproducibility, and interpretation of VAP rates [7]. In 2013, the National Healthcare Safety Network (NHSN) replaced the previous definition of pneumonia with a classification of ventilator-associated events (VAEs). The concept of VAEs was defined to overcome many of the limitations of traditional VAP definitions, with the aim of establishing definitions that are objective, reproducible, automated, and a powerful predictor of poor outcomes [8]. VAEs are common complications in patients undergoing mechanical ventilation in the intensive care unit (ICU) [9,10]. These can lead to further complications that can extend the duration of mechanical ventilation, the length of stay (LOS) in the ICU, as well as costs, morbidity, and mortality [11,12]. Therefore, we analyzed the patients who received mechanical ventilator support at Jeju Regional Trauma Center.

## METHODS

### Ethical statements

The study was approved by the Institutional Review Board of the Cheju Halla General Hospital (No. 2021-L06-01). Informed consent was waived due to the retrospective nature of the study.

### Design and sample

In this retrospective review, the study population comprised patients admitted to Jeju Regional Trauma Center between January 2020 and January 2021. For each patient, information regarding demographics (e.g., age and sex), injury characteristics, and clinical data were collected. Injury characteristics included injury mechanism (e.g., traffic accident, fall from height, slip down), Glasgow Coma Scale (GCS) score, Abbreviated Injury Scale (AIS), and Injury Severity Score (ISS). The GCS was calculated at the time of first contact with medical services before intubation and sedation. Clinical data were obtained from patients' electronic medical records. The data included hospital LOS in days, ICU LOS in days, and ventilator support days and other clinical and laboratory values such as positive end-expiratory pressure (PEEP), fraction of inspired oxygen ($FiO_2$), white blood cell count, hematocrit, hemoglobin, platelet count, serum creatinine, blood urea nitrogen, glomerular filtration rate (GFR), temperature, antimicrobial agents administered, and culture results.

### Ventilator-associated events

VAEs, as defined by the NHSN [4], were categorized as ventilator-associated conditions (VACs), infection-related ventilator-associated complications (IVACs), and possible VAP (PVAP). Patients classified as having VACs had a baseline period of 2 days of stable or improved $FiO_2$ or PEEP followed by deterioration of oxygenation. Those categorized as having IVACs met the criteria for VACs, had a core temperature $>38°C$ or $<36°C$ or had a white blood cell $>12,000$ or $<4,000$ cells/mm$^3$, and were administered eligible antimicrobial agents that were continued for more than 4 days. For PVAP, in addition to meeting the criteria for IVAC, patients had $>10^5$ colony-forming units in their tracheal aspirates and $>10^4$ colony-forming units of microorganisms in cultures of bronchoalveolar lavage specimens (Table 1) [13].

### Statistics

Demographics, injury characteristics, clinical data, comorbidities, and nosocomial complications were compared between the two groups. The independent t-test and Fisher exact test were used for continuous and categorical variables, respectively. A logistic regression model adjusted for age, sex, GCS score, GFR, chest and head AIS, and ISS was used to estimate odds ratios (ORs) and associated 95% confidence intervals (CIs) for VAE occurrence and in-hospital mortality. A Cox proportional hazard model was used for investigating the association between VAE occurrence and several variables over time. The Kaplan-Meier method and the log-rank test were used for estimating the VAE-free rate curve and for statistical comparisons between the two groups. All tests of significance were two-tailed, and a P-value of $<0.05$ was considered statistically significant. Statistical analyses were performed using R statistics ver. 4.0.2. (The R Foundation for Statistical Computing, Vienna, Austria; https://www.r-project.org/).

## RESULTS

From January 2020 to January 2021, 492 patients were admitted to Jeju Regional Trauma Center, of whom 210 patients received ventilator support. Among them, 84 patients had at least 4 calendar days of ventilator support. In accordant with 2013 CDC/

**Table 1.** NHSN VAE criteria

| NHSN surveillance guidelines for diagnosis of VAE | | |
|---|---|---|
| Name: description | Dependent qualification | Definition |
| VAC: new respiratory deterioration | ≥2 calendar days of stable or decreasing daily minimum PEEP or daily minimum $FIO_2$ | Followed by a daily<br>Minimum PEEP of ≥3 cm $H_2O$<br>OR<br>Minimum $FIO_2$ by >20 points sustained for ≥2 calendar days |
| IVAC: VAC+clinical signs of infection | Within 2 calendar days before or after onset of a VAC<br>Excludes the first 2 days of mechanical ventilation | Temperature: <36°C or >38°C<br>OR<br>Leukocyte count: ≤4,000 or ≥12,000 cells/$mm^3$<br>AND<br>One or more new antibiotics continued for ≥4 days |
| Possible VAP: IVAC+qualitative evidence of pulmonary infection | Within 2 calendar days before or after onset of a VAC<br>Excludes the first 2 days of mechanical ventilation | Gram staining of endotracheal aspirate or BAL showing ≥25 neutrophils and ≤10 epithelial cells per low-power field<br>OR<br>Positive culture from sputum, endotracheal aspirate, BAL, lung tissue |
| Probable VAP: IVAC+qualitative evidence of pulmonary infection | Within 2 calendar days before or after onset of a VAC<br>Excludes the first 2 days of mechanical ventilation | Positive culture of endotracheal aspirate ≥$10^5$ CFU/mL, positive BAL culture with ≥$10^4$ CFU/mL, or positive culture of protected specimen brush ≥$10^3$ CFU/mL<br>OR<br>One of the following (without requirement for purulent secretions):<br>Positive pleural fluid culture (where specimen was obtained during thoracentesis or initial placement of chest tube and NOT from indewelling chest tube)<br>Positive lung histopathology<br>Positive diagnostic test for legionella<br>Positive diagnostic test on respiratory secretions for influenza virus, respiratory syncytial virus, adenovirus, parainfluenza virus, rhinovirus, human metapneumovirus, coronavirus |

Highlights the stepwise respiratory deterioration associated with VAC, IVAC, possible pneumonia, and probable pneumonia with specific, objective criteria that define each category. Sputum cultures excludes the following: normal respiratory/oral flora, mixed respiratory/oral flora or equivalent; *Candida* species or yeast not otherwise specified; coagulase-negative *Staphylococcus* species; and *Enterococcus species*.
NHSN, National Healthcare Safety Network; VAE, ventilator-associated event; VAC, ventilator-associated condition; IVAC, infection-related ventilator-associated complication; PEEP, positive end-expiratory pressure; $FIO_2$, fraction of inspired oxygen; VAP, ventilator-associated pneumonia; BAL, bronchoalveolar lavage; CFU, colony-forming unit.
Adapted from Spalding et al. [13] with permission from Elsevier.

NHSN VAE surveillance criteria, those who were under 18 years old (n = 4), received extracorporeal membrane oxygenation therapy (n = 6), and had incomplete data (n = 1) were excluded from this study (n = 11). Finally, the study population comprised 73 patients, of whom 48 had no VAEs (65.8%), 16 met the definition for VACs (21.9%), three met the criteria for IVACs (4.1%), and six met the criteria for PVAP (8.2%). The subjects categorized as belonging to the no-VAE group had no VAEs during mechanical ventilatory support. The subjects in the VAE group had at least one VAE criterion (including VACs, IVACs, and PVAP). There were no significant differences in demographics, comorbidities, injury characteristics, clinical data, and laboratory values between the two groups (Table 2). Additionally, there were no significant differences in ICU LOS (P = 0.200), ventilator support days (P = 0.164), the incidence of nosocomial complications, and in-hospital mortality (P = 0.111) between the two groups (Tables 3, 4). However, the VAE subjects were more likely to have higher GCS scores (P = 0.012) and chest AIS (P = 0.024) (Tables 2, 5) and less likely to have normal kidney function as measured by the GFR (P = 0.001) (Table 3) than the no-VAE subjects. The VAE

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**Table 2.** Comparison of demographics, comorbidities, and injury characteristics by VAE status

| Variable | No VAE (n=48) | VAE (n=25) | P-value |
|---|---|---|---|
| Age (yr) | 57.6±19.1 | 64.4±16.5 | 0.138 |
| Sex | | | |
| Male | 62.5 | 80.0 | 0.207 |
| Female | 37.5 | 20.0 | |
| Comorbidity | | | |
| Hypertension | 37.5 | 40.0 | >0.999 |
| Diabetes mellitus | 8.3 | 20.0 | 0.287 |
| Chronic kidney disease | 0 | 8.0 | 0.218 |
| Cerebrovascular attack | 10.4 | 12.0 | >0.999 |
| Tumor | 0 | 8.0 | 0.218 |
| Liver disease | 6.2 | 0 | 0.512 |
| Mechanism of injury | | | |
| Traffic accident | 43.8 | 56.0 | 0.455 |
| Fall from height | 20.8 | 12.0 | 0.539 |
| Slip down | 14.6 | 16.0 | >0.999 |
| Struck by object | 6.2 | 12.0 | 0.689 |
| Glasgow Coma Scale score | 9.2±4.1 | 11.8±4.1 | 0.012* |
| Injury Severity Score | 25.8±10.2 | 23.2±11.2 | 0.813 |
| Abbreviated Injury Scale | | | |
| Head | 3.35±1.92 | 2.86±2.00 | 0.327 |
| Face | 0.41±0.90 | 0.45±1.01 | 0.858 |
| Chest | 1.43±1.60 | 2.36±1.53 | 0.024* |
| Abdomen | 0.92±1.34 | 0.68±1.17 | 0.469 |
| Extremity | 0.86±1.34 | 1.27±1.12 | 0.214 |
| External | 0.67±0.89 | 0.59±0.59 | 0.715 |

Values are presented as mean±standard deviation or percentage. P-value obtained using chi-square test and Student t-tests for categorical and continuous variables, respectively.
VAE, ventilator-associated event.
*P<0.05.

**Table 3.** Comparison of clinical characteristics and laboratory values by VAE status

| Variable | No VAE (n=48) | VAE (n=25) | P-value |
|---|---|---|---|
| Clinical values | | | |
| SBP (mmHg) | 130±51 | 134±47 | 0.760 |
| DBP (mmHg) | 77±29 | 79±27 | 0.843 |
| Pulse rate (/min) | 86±29 | 89±31 | 0.631 |
| Respiratory rate (/min) | 22±7 | 22±4 | 0.947 |
| Body temperature (°C) | 36.3±0.8 | 36.4±0.5 | 0.291 |
| Blood cell count | | | |
| WBC (×1,000 cells/mm$^3$) | 13.4±5.4 | 12.2±6.2 | 0.421 |
| Hemoglobin (g/dL) | 12.5±2.3 | 12.6±1.9 | 0.845 |
| Hematocrit (%) | 36.3±6.7 | 37.1±5.3 | 0.606 |
| Platelet (×1,000/μL) | 228±91 | 214±73 | 0.512 |
| Chemistry | | | |
| BUN (mg/dL) | 19±15 | 22±15 | 0.422 |
| Creatinine (mg/dL) | 0.9±0.5 | 1.7±2.4 | 0.125 |
| GFR (mL/min/1.73 m$^2$) | 98.5±46.5 | 68.4±27.8 | 0.001** |
| CRP (mg/dL) | 1.9±7.3 | 0.6±2.1 | 0.264 |
| CPK (U/L) | 366±331 | 441±482 | 0.508 |
| ABGA | | | |
| pH | 7.3±0.1 | 7.4±0.1 | 0.512 |
| $PaCO_2$ (mmHg) | 35.8±8.1 | 33.9±6.5 | 0.334 |
| $PaO_2$ (mmHg) | 165.7±69.9 | 137.6±58.1 | 0.094 |
| Saturation (%) | 97.6±4.3 | 97.4±3.3 | 0.836 |
| Lactate (mg/dL) | 35.5±22.0 | 49.5±33.7 | 0.508 |

Values are presented as mean±standard deviation. P-value obtained using Student t-tests for continuous variables.
VAE, ventilator-associated event; SBP, systolic blood pressure; DBP, diastolic blood pressure; WBC, white blood cell; BUN, blood urea nitrogen; GFR, glomerular filtration rate; CRP, C-reactive protein; CPK, creatine phosphokinase; ABGA, arterial blood gas analysis.
**P<0.01.

subjects had a higher number of bronchoscopies (P = 0.004) and were more likely to have acute respiratory distress syndrome (P = 0.021) than the no-VAE subjects (Table 4). Continuous values were converted to categorical values for logistic regression analysis. The cutoff values were set as 65 years for age, 3 points for AIS, 15 points for ISS, 7 points for GCS, and 75 mL/min/1.73 m$^2$ for GFR. In the multivariate analysis, the risk for VAE occurrence was 4.7-fold higher in patients with chest AIS ≥ 3 (OR, 4.73; 95% CI, 1.46–17.9) and 4.1-fold higher in those with a GFR < 75 mL/min/1.73 m$^2$ (OR, 4.15; 95% CI, 1.32–14.1). The in-hospital mortality risk was more than 4-fold higher in patients with a GFR < 75 mL/min/1.73 m$^2$ (OR, 4.19; 95% CI, 1.30–14.3) (Table 6). In addition, VAEs occurred in 50.0% of patients with a chest AIS ≥ 3 within 15 days of mechanical ventilatory support (Fig. 1). The median VAE-free duration of patients with a chest AIS ≥ 3 was significantly shorter than that of patients with a chest AIS < 3 (P = 0.013).

## DISCUSSION

To our best knowledge, this study is the first surveillance study of the incidence, risk factors, and outcomes with the newly defined concept of VAEs in trauma patients. The present study revealed that several factors were associated with VAE occurrence and in-hospital mortality in polytrauma patients.

The VAE group was more likely to have higher GCS scores, which were used to define the severity of traumatic brain injuries (TBIs) in several studies. Patients with TBIs often suffer from profound suppression of cellular immunity and impaired con-

sciousness [14], and they usually require endotracheal intubation and mechanical ventilatory care, both of which increased the incidence of VAP. Therefore, severe TBI patients were more vulnerable to VAP [15]. However, chest injury and the combination of chest injury and TBI were found to be independent predictors for the development of pneumonia in polytrauma patients [15]. This suggests that TBI itself was not associated with the development of pneumonia. Our results showed that patients in the VAE group had relatively higher GCS scores, although the GCS scores were not related to in-hospital mortality.

Second, blunt chest trauma may cause intra-thoracic organ injuries, which may lead to serious complication and mortality in polytrauma patients [16]. The risk of respiratory failure and subsequent pneumonia development depends on the severity of the chest injury [17]. Hofman et al. [18] reported that although chest trauma was not an independent risk factor for mortality, it was an independent risk factor for pneumonia. Their results showed that a chest AIS ≥3 in poly-traumatized patients was associated with an increased risk of pneumonia (OR, 4.193; P=0.004) in multivariate regression analysis. The present study showed similar results, in that the patient with a chest AIS ≥3 were likely to have a higher risk of VAE.

**Table 4.** Comparison of clinical outcomes by VAE status

| Variable | No VAE (n=48) | VAE (n=25) | P-value |
|---|---|---|---|
| MV day | 17.7±15.4 | 25.2±23.9 | 0.164 |
| Length of stay | | | |
| ICU in day | 26.3±22.0 | 33.7±25.7 | 0.200 |
| Hospital in day | 86.8±69.9 | 61.0±33.9 | 0.037* |
| Bronchoscopy | 3.9± 4.7 | 14.1±15.9 | 0.004** |
| Complication | | | |
| AKI | 4 (8.3) | 3 (12.0) | 0.931 |
| ARDS | 0 | 4 (16.0) | 0.021* |
| CPR | 4 (8.3) | 4 (16.0) | 0.548 |
| VTE | 7 (14.6) | 4 (16.0) | 1.000 |
| PTE | 8 (16.7) | 5 (20.0) | 0.975 |
| UTI | 3 (6.2) | 1 (4.0) | 1.000 |
| CRBSI | 1 (2.1) | 1 (4.0) | 1.000 |
| Unplanned intubation | 6 (12.5) | 7 (28.0) | 0.187 |
| Unplanned operation | 6 (12.5) | 4 (16.0) | 0.957 |
| Unplanned ICU transfer | 5 (10.4) | 6 (24.0) | 0.232 |
| In-hospital mortality | 11 (22.9) | 11 (44.0) | 0.111 |

Values are presented as mean±standard deviation or number (%). P-value obtained using chi square test and student t-tests for categorical and continuous variables, respectively.
VAE, ventilator-associated event; MV, mechanical ventilator; ICU, intensive care unit; AKI, acute kidney injury; ARDS, acute respiratory distress syndrome; CPR, cardiopulmonary resuscitation; VTE, venous thromboembolism; PTE, pulmonary thromboembolism; UTI, urinary tract infection; CRBSI, catheter-related blood stream infection.
*P<0.05; **P<0.01.

**Table 5.** Chest Abbreviated Injury Scale (AIS)

| AIS 2008 | Skeletal | Lung |
|---|---|---|
| 1 | Contusion | - |
| | 1 Rib fracture | - |
| 2 | 2 Rib fractures | Unilateral contusion with minor <1 lobe |
| | Sternal fracture | Pneumothorax, pneumomedisatinum |
| 3 | ≥3 Ribs | Unilateral contusion with major ≥1 lobe |
| | 3–5 Flail chest | Hemopneumothorax |
| 4 | ≥5 Flail chest | Bilateral contusion with major ≥1 lobe |
| | | Pneumothorax >50% collapse |
| | | Hemothorax >1,000 mL in unilateral cavity |
| 5 | Bilateral flail chest | Tension pneumothorax |

**Table 6.** Multivariate analysis of factors associated with VAE occurrence and in-hospital mortalit

| Variable | VAE occurrence | | In-hospital mortality | |
|---|---|---|---|---|
| | OR (95% CI) | P-value | OR (95% CI) | P-value |
| Male sex | 2.25 (0.66–8.81) | 0.2102 | 0.54 (0.15–1.90) | 0.3357 |
| Age ≥65 years | 0.95 (0.25–3.32) | 0.9365 | 2.14 (0.67–7.33) | 0.2167 |
| Injury Severity Score ≥15 | 0.30 (0.05–1.73) | 0.1841 | 1.96 (0.34–12.4) | 0.4554 |
| Abbreviated Injury Scale | | | | |
| Chest ≥3 | 4.73 (1.46–17.9) | 0.0135* | 0.48 (0.12–1.70) | 0.2662 |
| Head ≥3 | 1.24 (0.31–5.61) | 0.7615 | 0.49 (0.12–2.04) | 0.3151 |
| GFR <75 mL/min/1.73 $m^2$ | 4.15 (1.32–14.1) | 0.0170* | 4.19 (1.30–14.3) | 0.0181* |
| VAE (+) | | | 2.53 (0.67–10.1) | 0.1733 |

P-value obtained from logistic regression model.
VAE, ventilator-associated event; OR, odds ratio; CI, confidence interval; GFR, glomerular filtration rate.
*P<0.05.


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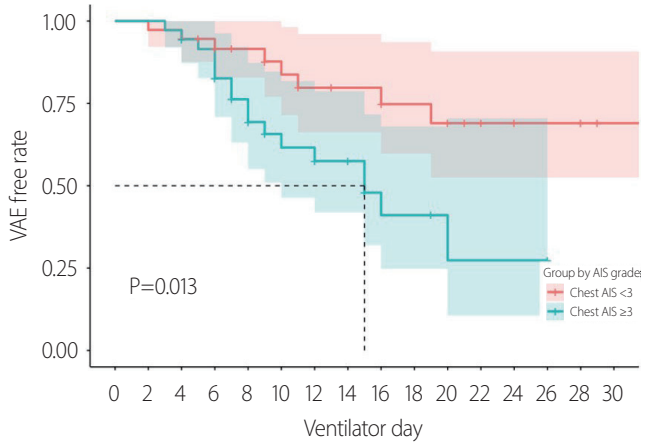


**Fig. 1.** Ventilator-associated event (VAE) free rate curves between low-grade and high-grade chest Abbreviated Injury Scale (AIS) group (estimated by the Kaplan-Meier log-rank test).

**Table 7.** Risk factor associated with posttraumatic acute kidney injury

| | GFR <75 mL/min/1.73 $m^2$ | GFR ≥75 mL/min/1.73 $m^2$ | P-value |
|---|---|---|---|
| Categorical values | | | |
| Male sex | 20 (27.4) | 30 (41.1) | 0.5993 |
| Hypertension | 15 (20.5) | 13 (17.8) | 0.0388* |
| Diabetes mellitus | 5 (6.8) | 4 (5.4) | 0.2765 |
| Continuous values | | | |
| Age (yr) | 66.5±16.3 | 56.0±18.7 | 0.0153* |
| ISS | 22.6±10.7 | 26.2±10.3 | 0.1648 |
| ICU stay (day) | 35.1±29.0 | 25.2±18.9 | 0.1179 |
| MVD | 26.7±25.4 | 16.5±12.8 | 0.0595† |

Values are presented as number (%) or mean±standard deviation. P-value obtained from t-test.
GFR, glomerular filtration rate; ISS, Injury Severity Score; ICU, intensive care unit; MVD, mechanical ventilator days.
*P<0.05; †P<0.1.

Lastly, several recent studies showed that reduced renal function was associated with an increased risk of pneumonia [19]. An explanation for this is that decreased renal function may increase the risk of infection due to immune impairment, which is supported by reports of abnormalities in neutrophil and lymphocyte function [20]. The observed association between kidney function and infection may be due to an increased susceptibility to infection and/or a greater severity of infection in older patients with chronic kidney disease [21]. Our study also showed similar results, as decreased renal function was associated with VAE occurrence and in-hospital mortality. VAEs themselves did not affect the risk of in-hospital mortality. However, patients with a low GFR showed a statistically significant increase in mortality. In other words, posttraumatic acute kidney injury (AKI) can be a direct risk factor for mortality in trauma patients. Harrois et al. [22] performed a systematic review and meta-analysis of AKIs in trauma patients that included 24 studies with 25,182 patients. In their analysis, they observed that posttraumatic AKI was associated with a 3.4-fold increased risk of mortality (95% CI, 2.1–5.7) and they observed that the risk factors for posttraumatic AKI were specific race, old age, hypertension, and diabetes mellitus. In our study, we performed a subgroup analysis based on GFR that showed statistically significant differences in patients' age (P = 0.0153) and hypertension (P = 0.0388) between the two groups (Table 7).

This study had several limitations. First, the study period was short, and the sample size was small. Although we were able to derive several risk factors associated with VAE occurrence and in-hospital mortality, it is necessary to estimate more significant risk factors using a largescale study in the future. Second, although the number of bronchoscopies was significantly higher (P = 0.004) in the VAE group, we were not able to establish a significant effect of bronchoscopy on VAE occurrence and in-hospital mortality. However, there is some evidence that diagnostic bronchoscopy may improve VAP-related outcomes [23,24]. Bronchoscopic sputum aspiration has also shown promising results and significant benefits in various indicators, including shorter mechanical ventilation, reduced hospital LOS, and improved weaning success rates [25]. Considering these points, it will also be necessary to study whether bronchoscopy may affect the occurrence and mortality rate of VAE in trauma patients. Third, in this study, the effect of tracheostomy was not considered in patients with a mechanical ventilator. However, tracheostomy may have several advantages, such as improved airway suctioning, less direct laryngeal injury, decreased airway resistance for promoting weaning from mechanical ventilation, and decreased risk for nosocomial pneumonia [26]. Thus, research on the association between tracheostomy and VAE occurrence is needed in the future.

In conclusion, based on our study results, traumatized patients with chest AIS ≥ 3 or GFR < 75 mL/min/1.73 $m^2$ on admission should be intensively monitored to detect patients at risk for VAEs and modify their care plans to reduce the risk of VAEs during mechanical ventilator support. VAEs should be closely monitored to identify infections in the target subjects early and to achieve desirable results. We should also actively consider modalities that can minimize the duration of mechanical ventilators (less than 15 days) in patients with a chest AIS ≥ 3 to reduce VAE occurrence.

## NOTES

### Ethical statements

The study was approved by the Institutional Review Board of the Cheju Halla General Hospital (No. 2021-L06-01). Informed consent was waived due to the retrospective nature of the study.

### Conflicts of interest

The authors have no conflicts of interest to declare.

### Funding

None.

### Author contributions

Conceptualization: TYL, JWO, MKL, JSK, JES; Data curation: TYL, JWO, JES, JHW; Formal analysis: MKL, JSK, JHW; Methodology: TYL, JWO, MKL, JES; Project administration: TYL, JWO; Visualization: JSK, JHW; Writing–original draft: all authors; Writing–review & editing: all authors.
All authors read and approved the final manuscript.

### Additional information

This study was posted at the 2021 Pan Pacific Trauma Congress (PPTC).

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# Age group analysis of patients with dog bite injuries who visited a single regional emergency medical center and factors affecting wound infections

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**Purpose:** The aim of this study was to analyze by age group the characteristics of patients with dog bite injuries, as well as determine which factors were associated with wound infections in those patients.

**Methods:** We reviewed patients with dog bite injuries who presented to Gachon University Gil Medical Center in Incheon, Korea from January 1, 2014 to December 31, 2018. They were classified by age group: children (0–18 years), adults (19–59 years), or elderly (≥60 years). Event profiles, wound characteristics, and infections were compared across these age groups. Multivariable logistic regression was used to identify factors associated with wound infections.

**Results:** Of the total 972 dog bite injuries, 272 (28.0%) were in children, 606 (62.3%) were in adults, and 94 (9.7%) were in the elderly. The median age was 30 years (interquartile range, 16–48 years) and the majority of patients (60.5%) were female. The most common place of injury was at home (73.8%) and indoors (77.0%). In children, the head and neck were the most frequent sites of injury (43%), while the most frequent site in adults and the elderly (50.8% and 59.6%, respectively) was the upper extremity. The odds ratio (OR) for wound infection was 3.997 (95% confidence interval [CI], 1.279–12.491; P=0.017) for head and neck injuries and 3.881 (95% CI, 1.488–10.122; P=0.006) for lower extremity injuries. The OR for wound infection was 4.769 (95% CI, 2.167–10.494; P<0.001) for significant injuries. Elderly patients had a higher risk for wound infection than other age groups (OR, 2.586; 95% CI, 1.221–5.475; P=0.013).

**Conclusions:** When analyzing patients with dog bite injuries, differences across age groups were found, with the elderly at the highest risk for significant injury and wound infection. It is recommended that age-specific approaches and strategies be used to prevent dog bite wound infections.

**Keywords:** Wounds and injuries; Infections; Age groups; Bites and stings; Dogs

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## INTRODUCTION

The number of households with pets has been increasing yearly, with an estimated 63 million dogs raised as pets in the United States [1] and approximately 5 million dogs and 2 million cats raised as pets in Korea [2]. With increased animal contact, the incidence of animal bite injuries and resulting medical expenditures are on the rise, becoming an important public health issue [3,4]. Animal bite injuries account for 1% of patients treated in the emergency department (ED) in the United States; in Korea, approximately 1 million cases of animal bite injuries occur annually [3].

Many types of injuries can result from dog bites, including lacerations and fractures, and dog bites there require varied types of treatment, from simple wound dressings to suturing and/or surgery. Moreover, a dog's oral secretions contain many types of bacteria [5], contributing to a high risk for bite wound infection. To prevent infections, appropriate post-bite wound care is important, and studies of the injury mechanism, wound features, treatment, and preventive measures are crucial. Several studies of animal bites, including dog bites, have been conducted [6–9]. However, in Korea most studies had a small sample size and studies of treatment or prognosis were lacking [10–12]. Therefore, this study compared by age group the characteristics and treatments for dog bite injuries among patients who presented to a single regional emergency medical center, and analyzed the risk factors for wound infection.

## METHODS

### Ethical statements

This study was approved by the Institutional Review Board of Gachon University Gil Medical Center (No. GCIRB2021-098). Informed consent was waived due to the retrospective nature of the study.

### Study design and population

This retrospective study analyzed patients who presented with a dog bite to Gachon University Gil Medical Center, a single regional emergency medical center in Incheon, Korea, from January 1, 2014 to December 31, 2018. The participants were patients whose injury mechanism was a dog bite. Data were obtained from the hospital's ED-based Injury In-depth Surveillance (EDIIS) registry. The injury narratives recorded in the EDIIS were checked to exclude patients who were bitten by different animals or persons, as well as patients who had injuries from a dog other than a bite.

### Data collection and variables

The study data was collected from the EDIIS registry and patients' medical records. The EDIIS was established by the Korea Disease Control and Prevention Agency (KDCA) in 2006. The number of participating hospitals in this surveillance has increased from five to 23 hospitals nationwide. A trained coordinator at each hospital registers the data for 246 variables in the KDCA online system, including patient demographics, injury-related profiles, prehospital records, diagnosis, disposition, and outcomes. The KDCA manages the quality of the input data through periodic error analyses.

From the EDIIS registry, information was collected about the patients, including age, sex, mode of transportation to the ED, time and place of injury, dog owner, site of injury, surgery, and ED disposition. In addition, information about wound characteristics, treatments, and infections was collected from the medical records.

Patients were divided into three groups for analysis: children (0–18 years), adults (19–59 years), and the elderly (≥60 years). The season of injury was divided into four categories: spring (March–May), summer (June–August), fall (September– November), and winter (December–February). The time of injury was classified as day (08:00–16:00), evening (16:00–24:00), or night (00:00–08:00). The place of injury (place 1) was classified as home, road, commercial facility, public cultural facility, or other; and additionally into indoors or outdoors (place 2). Dog owner categories were divided by relationship into household/relative, neighbor/friend, stranger, or unknown. The anatomical sites of injury were divided into head and neck, torso, upper extremity, or lower extremity. Injuries at two or more sites were considered multiple sites.

Wound characteristics were categorized as superficial, open, muscle or tendon injuries, fracture, or amputation. Methods of wound treatment were divided into primary suturing, delayed suturing, local wound care, and unknown. A significant injury was defined as a dog bite injury that led to death, hospitalization, or surgery or caused a muscle/tendon injury, fracture, or amputation [11]. Wound infection was defined as the presence of systemic fever, local abscess, or lymphangitis. Further evidence of wound infection included erythema, swelling, increased temperature/tenderness, or drainage from the wound [13].

### Statistical analysis

Statistical analysis was conducted using IBM SPSS ver. 23.0 (IBM

Corp., Armonk, NY, USA). To compare the characteristics among age groups, categorical data were analyzed using the chi-square test or the Fisher exact test, and continuous variables were analyzed using the ANOVA or Kruskal-Wallis H test, depending on the normality of the data. The predictors of significant injury and wound infection were identified using multivariate logistic regression at $P < 0.01$, by including clinically significant factors in the analysis. To identify the factors associated with significant injury, multivariate logistic regression was performed with the inclusion of age group, sex, mode of transportation to the ED, time of injury, dog owner familiarity, place 2, and bite site as variables. The factors associated with wound infection were analyzed with the inclusion of age group, sex, mode of transportation to the ED, time of injury, dog owner familiarity, place 2, bite site, primary suture, and significance of the injury as variables. Statistical significance was set at $P < 0.05$.

## RESULTS

### General characteristics

During the study period, 975 patients presented to the ED with a dog bite injury. After excluding two patients with a human bite and one patient with a cat bite, a total of 972 patients were analyzed. By age group, there were 272 children (28.0%), 606 adults (62.3%), and 94 elderly (9.7%). The median age was 30 years (interquartile range, 16–48 years), with most patients aged 20 to 29 years (Fig. 1). Overall, there were more female patients (60.5%), and the category of children had the lowest percentage of male patients (48.2%) (Table 1).

The elderly most frequently arrived at the ED via a public ambulance (17.0%). The most common place of injury in all age groups was at home, followed by roads, with 77% of the injuries occurring indoors. The incidence of outdoor injuries increased with age and was significantly higher among the elderly than among other age groups (36.4%; $P = 0.003$). In terms of ownership, 620 patients (63.8%) were bitten by a dog they owned themselves or that their family owned. There were no significant differences in the season of injury among the age groups ($P = 0.062$). The injuries most commonly occurred in the evening in all age groups (58.2%), followed by day and night, respectively. The most common anatomical site of injury in children was the head and neck region, while the upper extremity was most common among the elderly. These differences were statistically significant ($P < 0.001$ and $P < 0.001$, respectively). Twenty-five patients had multiple injuries, most of whom were adults (n = 14, 2.3%).

### Wound characteristics and treatments

Superficial injuries were most common in children, while open wounds were most common in the elderly; however, there were no statistically significant differences. The incidence of muscle or tendon injuries (10.6%, $P = 0.004$) and fractures (4.2%, $P = 0.001$) was highest in the elderly (Table 2). After ED treatment, 938 patients (96.5%) were discharged and 23 (2.4%) were admitted to the general ward. One patient was admitted to the intensive care unit due to loss of consciousness related to drinking. There were no deaths.

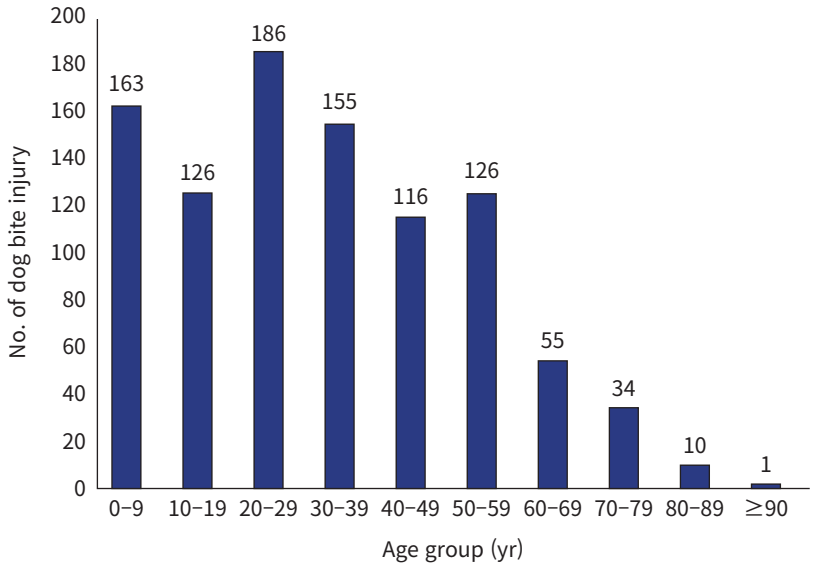


**Fig. 1.** Distribution of patients with dog bite injuries by age group.

**Table 1.** Age group characteristics and dog bite event profiles

| Characteristic | Total (n=972) | Age group | | | P-value |
|---|---|---|---|---|---|
| | | Children (n=272) | Adults (n=606) | Elderly (n=94) | |
| Age (yr) | 30 (16–48) | 7 (2–12) | 35 (26–48) | 68 (63–76) | |
| Male sex | 384 (39.5) | 131 (48.2) | 220 (36.3) | 33 (35.1) | 0.003 |
| Public ambulance | 71 (7.3) | 16 (5.9) | 39 (6.4) | 16 (17.0) | 0.010 |
| Place 1 | | | | | 0.002 |
| Home | 717 (73.8) | 211 (77.6) | 435 (71.8) | 71 (75.5) | |
| Road | 115 (11.8) | 28 (10.3) | 70 (11.6) | 17 (18.1) | |
| Commercial facilities | 77 (7.9) | 13 (4.8) | 62 (10.2) | 2 (2.1) | |
| Public facilities | 39 (4.0) | 17 (6.3) | 21 (3.5) | 1 (1.1) | |
| Others | 24 (2.5) | 3 (1.1) | 18 (3.0) | 3 (3.2) | |
| Place 2 | | | | | 0.003 |
| Indoor | 748 (77.0) | 220 (81.9) | 468 (77.2) | 60 (63.8) | |
| Outdoor | 224 (23.0) | 52 (19.1) | 138 (22.8) | 34 (36.2) | |
| Familiarity | | | | | 0.480 |
| Family/relatives | 620 (63.8) | 183 (67.3) | 379 (62.5) | 58 (61.7) | |
| Neighbor/friend | 131 (13.5) | 36 (13.2) | 78 (12.9) | 17 (18.1) | |
| Stranger | 164 (16.9) | 37 (13.6) | 113 (18.6) | 14 (14.9) | |
| Unknown | 57 (5.9) | 16 (5.9) | 36 (5.9) | 5 (5.3) | |
| Season | | | | | 0.062 |
| Spring | 248 (25.5) | 65 (23.9) | 162 (26.7) | 21 (22.6) | |
| Summer | 265 (27.3) | 71 (26.1) | 162 (26.7) | 32 (34.0) | |
| Fall | 223 (22.9) | 57 (21.0) | 138 (22.8) | 28 (29.8) | |
| Winter | 236 (24.3) | 79 (29.0) | 144 (23.8) | 13 (13.8) | |
| Time | | | | | <0.001 |
| Day (08:00–16:00) | 283 (29.1) | 80 (29.4) | 166 (27.4) | 37 (39.4) | |
| Evening (16:00–00:00) | 566 (58.2) | 180 (66.2) | 335 (55.3) | 51 (54.3) | |
| Night (00:00–08:00) | 123 (12.7) | 12 (4.4) | 105 (17.3) | 6 (6.4) | |
| Bite site[a)] | | | | | |
| Head and neck | 310 (31.9) | 117 (43.0) | 178 (29.4) | 15 (16.0) | <0.001 |
| Torso | 24 (2.5) | 9 (3.3) | 12 (2.0) | 3 (3.2) | 0.449 |
| Upper extremity | 464 (47.7) | 100 (36.8) | 308 (50.8) | 56 (59.6) | <0.001 |
| Lower extremity | 208 (21.4) | 52 (19.1) | 128 (21.1) | 28 (29.8) | 0.091 |
| Multiple | 25 (2.6) | 5 (1.8) | 14 (2.3) | 6 (6.4) | 0.045 |

Values are presented as median (interquartile range) or number (%).
[a)]Sums of the proportions exceed 100% because of the presence of multiple injury.

Localized wound care, without more invasive interventions such as suturing and/or surgery, was performed in 63.0% of the patients. The percentage of patients who underwent primary and delayed suturing was highest in children (23%) and the elderly (17%), with a significant difference among the age groups (P < 0.001). A total of 932 patients were prescribed antibiotics in the ED and the most prescribed antibiotic was amoxicillin/clavulanate (83.4%). Surgery was performed in 16 patients (1.6%), including seven who were elderly.

Of the 55 patients who sustained a significant injury, 4.4% were children, 4.8% adults, and 14.9% elderly (P < 0.001). Seventy-five patients were lost to follow-up and excluded from the study. Of the remaining 892 patients, 10.7% developed wound infections; the highest rate was found in the elderly (22.0%) and the lowest rate in children (7.7%; P = 0.009).

## Factors associated with significant injury and wound infection

The factors associated with significant injury, analyzed by multivariate logistic regression, are shown in Table 3. The odds ratio (OR) for significant injury was 3.566 (95% confidence interval [CI], 1.720–7.395; P = 0.001) when the patient was transported to

**Table 2.** Characteristics and management of dog bite wounds

| Variable | Total (n=972) | Age group | | | P-value |
|---|---|---|---|---|---|
| | | Children (n=272) | Adults (n=606) | Elderly (n=94) | |
| Wound characteristic[a)] | | | | | |
| Superficial | 530 (54.5) | 161 (59.2) | 325 (53.6) | 44 (46.8) | 0.089 |
| Open | 455 (46.8) | 114 (41.9) | 290 (47.9) | 51 (54.3) | 0.236 |
| Muscle/tendon | 36 (3.7) | 6 (2.2) | 20 (3.3) | 10 (10.6) | 0.001 |
| Fracture | 10 (1.0) | 1 (0.4) | 5 (0.8) | 4 (4.3) | 0.004 |
| Amputation | 3 (0.3) | 0 | 2 (0.3) | 1 (1.1) | 0.273 |
| ED disposition | | | | | 0.002 |
| Discharge | 938 (96.5) | 262 (96.3) | 591 (97.5) | 85 (90.4) | |
| Admission (ward) | 23 (2.4) | 8 (2.9) | 7 (1.2) | 8 (8.5) | |
| Admission (ICU) | 1 (0.1) | 0 | 1 (0.2) | 0 | |
| Transfer | 5 (0.5) | 0 | 5 (0.8) | 0 | |
| DAMA | 5 (0.5) | 2 (0.7) | 2 (0.3) | 1 (1.1) | |
| Suture | | | | | <0.001 |
| Primary | 201 (20.7) | 63 (23.2) | 127 (21.0) | 11 (11.7) | |
| Delayed | 84 (8.6) | 19 (7.0) | 49 (8.1) | 16 (17.0) | |
| Local wound care | 612 (63.0) | 180 (66.2) | 378 (62.4) | 54 (57.4) | |
| Unknown | 75 (7.7) | 10 (3.7) | 52 (8.6) | 13 (13.8) | |
| Antibiotics | | | | | 0.752 |
| Amoxicillin/clavulanate | 811 (83.4) | 221 (81.3) | 514 (84.8) | 76 (80.9) | |
| Cephalosporin | 117 (12.0) | 36 (13.2) | 67 (11.1) | 14 (14.9) | |
| Others | 4 (0.4) | 2 (0.7) | 2 (0.3) | 0 | |
| None | 40 (4.1) | 13 (4.8) | 23 (3.8) | 4 (4.3) | |
| Surgery | 16 (1.6) | 6 (2.2) | 3 (0.5) | 7 (7.4) | <0.001 |
| Significant injury | 55 (5.7) | 12 (4.4) | 29 (4.8) | 14 (14.9) | <0.001 |
| Wound infection[b)] | 97 (10.9) | 20 (7.7) | 59 (10.7) | 16 (22.0) | 0.009 |

Values are presented as number (%).
ED, emergency department; ICU, intensive care unit; DAMA, discharge against medical advice.
[a)]Sums of the proportions exceed 100% because of the presence of multiple injury. [b)]Excluding 75 patients with follow-up loss, 892 patients were included.

**Table 3.** Risk factors associated with significant injuries from dog bites

| Variable | Adjusted OR | 95% CI | P-value |
|---|---|---|---|
| Age group | | | |
| Children | Reference | - | 0.031 |
| Adults | 1.185 | 0.557–2.523 | 0.659 |
| Elderly | 2.880 | 1.176–7.054 | 0.021 |
| Public ambulance | 3.566 | 1.720–7.395 | 0.001 |
| Time (night) | 0.621 | 0.345–1.118 | 0.112 |
| Familiarity | 0.551 | 0.248–1.224 | 0.143 |
| Place (outdoor) | 2.498 | 1.290–4.838 | 0.070 |
| Upper extremities | 2.135 | 1.151–3.959 | 0.016 |

OR, odds ratio; CI, confidence interval.

**Table 4.** Risk factors associated with infection of dog bite wounds

| Variable | Adjusted OR | 95% CI | P-value |
|---|---|---|---|
| Age group | | | |
| Children | Reference | - | 0.045 |
| Adults | 1.413 | 0.815–2.450 | 0.218 |
| Elderly | 2.586 | 1.221–5.475 | 0.013 |
| Public ambulance | 1.955 | 0.962–3.973 | 0.064 |
| Head and neck | 3.997 | 1.279–12.491 | 0.017 |
| Upper extremities | 6.337 | 2.399–16.744 | <0.001 |
| Lower extremities | 3.881 | 1.488–10.122 | 0.006 |
| Primary suture | 2.166 | 0.976–4.808 | 0.058 |
| Significant injury | 4.769 | 2.167–10.494 | <0.001 |

OR, odds ratio; CI, confidence interval.


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the ED by ambulance, 2.880 (95% CI, 1.176–7.054; P = 0.021) in the elderly, and 2.135 (95% CI, 1.151–3.959; P = 0.016) for upper extremity injuries.

The factors associated with wound infections are shown in Table 4. The highest OR for wound infection, 6.337 (95% CI, 2.399–16.744; P < 0.001) occurred in upper-extremity injuries, followed by injuries to the head and neck (OR, 3.997; 95% CI, 1.279–12.491; P = 0.017) and lower extremities (OR, 3.881; 95% CI, 1.488–10.122; P = 0.006). The OR for significant injury was 4.769 (95% CI, 2.167–10.494; P < 0.001). By age group, the elderly had a higher risk for wound infection than children, with an OR of 2.586 (95% CI, 1.221–5.475; P = 0.013).

## DISCUSSION

This study examined the characteristics of patients with dog bite injuries and identified the factors associated with wound infection according to patient age groups. In particular, the elderly (age ≥ 60 years) had more outdoor injuries, upper and lower extremity injuries, and a higher risk of significant injury and/or wound infection. In order to prevent wound infection, healthcare providers must be careful during wound management (e.g., irrigation and debridement) and patients need to be actively educated about wound infection prevention.

In 2005, Kim et al. [11] reported a higher incidence of dog bite injuries in male patients, whereas this study found a higher percentage in female patients (60.5%). Our study results were similar to the results of another recent Korean study [10,12] as well as studies published in other countries [14]. This difference may be attributable to changes in pet culture since the study by Kim et al. [11] in 2005. The incidence of injury was high among people in their 20s and 30s and children under the age of 10, which is similar to previous reports [10–12]. Home was the most common place of injury among children compared to other age groups, which is also consistent with previous reports [10,11]. However, in this study, the rate of outdoor injuries increased with age, with 36.4% of injuries sustained outdoors among the elderly. The reason for this seems to be that children, unlike adults, spend more time at home. However, a lack of studies that specifically analyzed the older adult population makes it difficult to compare our findings to other reports. It has been reported that the incidence of dog bite injury increases during longer daylight seasons when temperatures are favorable for outdoor activities [8,10,15]. In this study, the difference between seasons was not statistically significant. Injuries were most commonly sustained in the evening, which is consistent with a previous study that reported that injuries frequently occur during the more active times of day.

When looking at the site of dog bite injury, head and neck injuries were the most common in children, whereas upper extremity injuries became more frequent with increasing age [11,15]. Our results are in line with previous findings, showing significant differences in the site of injury across age groups. Upper extremity injuries were most common in the elderly and the rate of lower extremity injuries was also high in this age group (29.8%) when compared to the overall study population (21.4%). The reason for the high rate of head and neck bites in children may be explained by patient height [11]. That is, because children are relatively short, they sustained facial injuries more frequently than taller adults who experienced more upper extremity injuries. Adults are also more likely than children to use their arms and legs in self-defense during an attack. Head and neck injuries were the second-most common injury in adults, probably because facial contact with a dog is a common expression of intimacy. Lower extremity injuries were the second-most common injury in the elderly.

In this study, superficial injuries were common among children and adults, while open wounds were most common among the elderly. While Park et al. [10] reported that 79.2% of dog bite injuries were open wounds, Kim et al. [11] reported that puncture injuries were the most common. The difference can probably be attributed to variations in the classification of wound types. Localized wound care was the most common treatment in all age groups. The rate of primary suturing was 23.2% in children and the rate of delayed suturing was 17.0% in the elderly, similar to the results of a previous study [11]. The vascular system of the head and neck area is more developed, contributing to a lower risk of infection after suturing. Primary suturing is reported to lead to relatively good outcomes. However, healing by secondary intention (secondary wound closure) is generally recommended for other sites [16,17]. Children in this study most commonly had head and neck injuries, with a high rate of primary suturing. Amoxicillin/clavulanate was the primary prophylactic antibiotic administered for dog bite wounds [16], and in this study it was prescribed for 83.4% of the patients. Overall, 2.4% of the total patients were hospitalized, as compared to varying hospitalization rates in previous studies (1.8%–11.1%) [8,10,12,15,18]. The rate of significant injury (5.7%) was associated with old age, transport by ambulance, and upper extremity injury. Park et al. [10] reported that in addition to old age, multiple site injuries and head and neck injuries were also associated with significant injury. Another study reported that upper extremity or

multiple site injuries were also associated with hospitalization [19].

The overall incidence of dog bite wound infection is 5% to 10%, though the incidence increases to 12% to 30% for some sites of injury [6,20,21]. In this study, 10.9% of the patients developed a wound infection, with a rate of 7.7% among children and 22.0% among elderly patients. Primarily, old age, head and neck injuries, upper extremity and/or lower extremity injuries, and significant injuries were identified as factors associated with wound infection. A previous study reported the incidence of infection to be 1.9% before age 50 years and 11.8% after age 50 years. Other factors associated with infection were full thickness wounds, debridement, and female sex [6]. The high rate of infection in the elderly seems to be influenced by the high rate of upper and lower extremity injuries and significant injuries in this age group. Second, the mechanism of the bite also has an impact on infections. For example, the upper extremities, especially the fingers, are often bare and completely exposed to the dog's oral secretions during a bite, leaving them more susceptible to infection than a covered part of the body. Third, various underlying diseases, including diabetes, may increase the risk of infection. In this study, head and neck injuries were found to be associated with infection. In general, the head and neck area feature a well-developed vascular network compared to other areas, and thus, the benefits of primary suturing help offset the risk of infection. A study comparing facial injuries that were immediately closed with sutures to injuries that were treated without suturing reported that immediate closure did not increase the risk of infection [9]. However, dogs' oral secretions contain numerous microorganisms, which can cause infection [16,20,22,23], so precautions should be taken against infection for all dog bite wounds.

This study had several limitations. First, this was a single-center study; thus, the generalizability of the findings is limited, and the results may need to be validated in a larger study. Second, because this was a retrospective study, it was not possible to control for possible errors in classification caused by incomplete or inaccurate data entered into the medical records. Third, 7.7% (n = 75) of the participants were lost to follow-up; therefore, their data on wound suture type and infection were not available, which may have affected the study results. Prospective studies are needed to better analyze factors related to dog bite injuries and wound infection. Information such as dog species and size, patient height, and wound size could be meaningful.

In conclusion, dog bite injuries have differing characteristics across age groups. Indoor injuries and head and neck injuries were common among children, while upper extremity injuries were common in adults and the elderly. The rate of outdoor injuries increased with age. Additional precautions are necessary when assessing and treating dog bite wounds in elderly patients who are at high risk of significant injury and infection. Because dog bites in all anatomical areas are associated with infection, after appropriate initial care patients should be encouraged to attend outpatient follow-up visits for an adequate period and should be hospitalized if necessary.

## NOTES

### Ethical statements

This study was approved by the Institutional Review Board of Gachon University Gil Medical Center (No. GCIRB2021-098). Informed consent was waived due to the retrospective nature of the study.

### Conflicts of interest

The authors have no conflicts of interest to declare.

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### Author contributions

Conceptualization: all authors; Data curation: DHK, JYC, JHJ, JSC, SYH; Formal analysis: all authors; Methodology: all authors; Project administration: JYC; Visualization: DHK, JYC, JHJ; Writing–original draft: DHK, JYC, WSC; Writing–review & editing: DHK, JYC, JSC, SYH.

All authors read and approved the final manuscript.

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# The incidence of unexpected delays in uploading outside radiologic images in the transfer of patients with major trauma

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**Purpose:** Critically ill patients are frequently transferred from one point of care to a hospital that can provide a higher level of care. To achieve optimal treatment within the targeted window of time necessary for time-sensitive cases like major trauma, rapid transportation and decision making are essential. Transferred patients have often undergone radiologic imaging at the referring hospital. Examining these outside images is paramount. Therefore, this study was conducted to estimate the upload time of outside images.

**Methods:** This retrospective study was conducted from January to April 2020. Patients transferred from other hospitals with digitally recorded CDs or DVDs of radiologic or diagnostic images were included. When the patients were registered at the emergency department reception desk, the digital images were transmitted to our picture archiving and communication system using transmission software. The time of upload and the numbers of digital images were recorded. The time interval from patient registration to the time of upload was calculated.

**Results:** The median number of images was 688 in the trauma team activation (TTA) group (688 in the TTA group, 281 in the non-TTA trauma group, and 176 in the nontrauma group, respectively; P<0.001). The median upload time was 10 minutes. The longest upload time was 169 minutes. The upload time was more than 20 minutes in 12 cases (19.4%).

**Conclusions:** Patients with major trauma bring more images than patients with other diseases. Unexpected delays (>20 minutes) were noted in approximately 20% of cases. It is necessary to minimize this time.

**Keywords:** Trauma centers; Wounds and injuries; Teleradiology; Telemedicine

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## INTRODUCTION

Critically ill patients are frequently transferred to a hospital that can provide a higher level of care. Acute myocardial infarction (AMI), acute stroke, and major trauma are time-sensitive diseases and are also the three major categories of severe medical emergencies in Korea. For AMI, the recommended time from the first medical contact to percutaneous coronary intervention is 70 minutes (120 minutes including transfer time if the patient first visits a percutaneous coronary intervention noncapable institu-

tion) [1–3]. Fibrinolysis is recommended, when indicated, within 3 hours of symptom onset in acute ischemic stroke [4,5]. In major trauma, the concept of the "golden hour" or time from the accident to definitive care is important and the recommended allowed time in the field is less than 10 minutes [6,7].

In recent years, cardiovascular centers or trauma centers have been established and helicopter emergency medical services (HEMS) have become available, reducing the mortality and complications of these diseases in Korea. Of the 389,269 AMI, acute stroke, and major trauma patients in 2019, 5.9% were transferred to other hospitals [8]. To achieve the right treatment at the right time for these time-sensitive diseases, rapid transportation and decision making are essential. Sometimes, the transferred patients have undergone radiologic imaging at the referring hospital. It is paramount that the physicians in the receiving hospital examine these outside images. Therefore, this study was conducted to estimate the upload time of outside images to our picture archiving and communication system (PACS; ViewRex 3, Techheim, Seoul, Korea).

## METHODS

This is a retrospective study conducted at Dankook University Hospital, an academic tertiary medical center in Korea. The approval from the Institutional Review Board and informed consents were not obtained due to the retrospective and observational nature of the study. The study period was from January to April 2020. Dankook University Hospital is a regional emergency center and level I trauma center where a physician-staffed HEMS is available. Emergency cardiac angiography and acute stroke care are available 24 hours per day, 7 days per week. Therefore, many patients are transferred to this institution. Approximately 42,000 patients visit the emergency department (ED) annually. During the study period, patients transferred from other hospitals with digitally recorded radiologic or diagnostic images on CD or DVD were included. This study excluded patients with radiologic images on film, those with paper electrocardiography strips, and those with only a medical record or referral order without digital images. On arrival at our ED, the patient was registered at the reception desk and if a CD/DVD accompanied them, the digital images were transmitted to our PACS using transmission software. A few minutes later, the images from the referring hospital were available for review on our PACS. The time of upload and the number of digital images were recorded. The time interval from patient registration to the time of upload was calculated. The time intervals for X-ray images, computed tomography (CT) scans, and magnetic resonance imaging (MRI) were estimated separately, and the final upload time was defined as the longest time interval (the last uploaded images) among them.

The digital images were categorized as follows: X-ray, CT, MRI, electrocardiography, angiography, endoscopy, and ultrasonography. Ultrasonography included obstetric or traumatic ultrasonography and cardiac echocardiography. According to the body parts imaged, facial and cranial X-ray images were classified as head X-rays (skull series, water's view, orbital view, nasal view, etc.). Neck images, such as those of the cervical spine and lateral neck or air tracheograms, were classified as cervical spine X-rays. Chest X-rays included chest posteroanterior/anteroposterior images, rib series, and lateral sternum. Abdominal X-rays included the abdomen, erect/supine, or kidney/ureter/bladder. Classifications for CT scans included brain and facial CT, classified separately. Again, the major examined body parts were considered; thereby, CT pulmonary angiography was classified as chest CT and vascular CT for the detection of arteriosclerosis obliterans or deep vein thrombosis was classified as extremity CT.

The categorical data were shown as numbers and percentages. The numerical data were represented as mean ± standard deviation or median (interquartile range). Frequency was compared using the chi-square method. Mean values were compared using the Kruskal-Wallis test or Mann-Whitney U-test as appropriate. Statistical analysis was conducted using IBM SPSS ver. 24.0 (IBM Corp., Armonk, NY, USA) and P-values below 0.05 were considered statistically significant.

## RESULTS

This study enrolled 321 patients who were treated during the study period. Their mean age was 58.9 years and 190 (59.2%) were male patients. Of these, there were 148 trauma patients (46.1%) and the trauma team was activated in 62 cases (19.3%). Eight patients were categorized as having ischemic stroke, seven as having hemorrhagic stroke, 105 as having a medical disease, and 13 as having a surgical disease. Of the 321 patients enrolled, 133 (41.4%) were admitted and 147 (45.8%) were discharged from the ED (Table 1).

### Outside images based on radiologic modality

The most frequently conducted X-rays at the referring hospitals (225, 70.1%) were chest X-rays (Table 2). The median number of chest X-ray images was one. The median upload time was 14 minutes; the longest time was 83 minutes. Brain CT was the most

**Table 1.** The characteristics of transfer patients with digital images from the referring hospital

| Characteristic | Value |
|---|---|
| Age (yr) | 58.9±21.2 (0–90) |
| Male sex | 190 (59.2) |
| Korean triage and acuity scale | |
| I | 31 (9.7) |
| II | 53 (16.5) |
| III | 143 (44.5) |
| IV | 84 (26.2) |
| V | 10 (3.1) |
| Systolic blood pressure (mmHg) | 136.4±30.0 |
| Diastolic blood pressure (mmHg) | 80.7±18.0 |
| Heart rate (/min) | 89.3±21.5 |
| Respiration rate (/min) | 17.5±5.9 |
| Body temperature (°C) | 36.5±0.8 |
| Disease categories | |
| Trauma | 148 (46.1)[a] |
| Medical disease | 105 (32.7) |
| Ischemic stroke | 8 (2.5) |
| Hemorrhagic stroke | 7 (2.2) |
| Other neurologic disease | 15 (4.7) |
| Drug intoxication | 1 (0.3) |
| Postcardiac arrest status | 18 (5.6) |
| Psychiatric disease | 1 (0.3) |
| Surgical disease | 13 (4.0) |
| Peripheral vascular disease | 2 (0.6) |
| Foreign bodies | 3 (0.9) |
| Trauma team activation | 62 (19.3) |
| Treatment outcome | |
| Admission | 133 (41.4) |
| Discharge from emergency department | 147 (45.8) |
| Transfer | 20 (6.2) |
| Discharge against medical advice | 15 (4.7) |
| Expired | 6 (1.9) |

Values are presented as mean±standard deviation (range), number (%), or mean±standard deviation.
[a]Trauma team activation patients were 62 in numbers. However, the final diagnoses of three patients were not traumatic among these 62 patients (one cerebral infarction, two herniated disc).

common CT from the referring hospitals, followed by chest and abdominal CT. Brain CT was reviewed in 167 patients (52%) and the median number of CT images was 118. The median upload time was 12 minutes (maximum, 78 minutes). Nineteen patients came with brain MRI images. The median number of brain MRI images was 198. The median upload time was 16 minutes (maximum, 74 minutes). The median number of images was the largest in angiography (median, 1,041).

### The number of images and upload times according to disease category

Among trauma patients, the trauma team was activated in 62 and not activated in 89. There were 170 nontraumatic patients. Chest, pelvis, and cervical X-rays and brain, face, chest, abdominal, and cervical CT scans were frequently done at the referring hospitals in the trauma team activation (TTA) group (Table S1).

In the subgroup analysis, the number of images was higher and the upload time was shorter in the TTA group than in the nontrauma or non-TTA trauma groups. No significant differences were observed between the nontrauma and non-TTA trauma groups. The median number of images was higher (688, 281, and 176, respectively; $P < 0.001$), and the median upload time was shorter (10, 14, and 15 minutes, respectively; $P = 0.001$) in the TTA group (Table 3). The longest upload time was 169 minutes. The upload time was longer than 20 minutes in 12 cases (19.4%) (Fig. 1).

### The number of images and upload times between the TTA groups and the stroke group

The median number of images was higher in the TTA group than in the stroke group (688.0 vs. 159.5, $P = 0.009$) (Table 4). The median upload time was longer, but the difference was not statistically significant (10.0 minutes vs. 7.5 minutes, $P = 0.123$).

## DISCUSSION

AMI, acute stroke, and major trauma are time-sensitive diseases. These are also the three major categories of severe emergency diseases in Korea. Of the 389,269 patients with these diseases, 22,867 (5.8%) were transferred to other hospitals [8] including 1,865 of the 37,988 patients with AMI, 7,212 of the 120,584 with acute stroke, and 13,790 of the 230,697 with major trauma. Currently, 17 level I trauma centers exist in Korea and specialty hospitals for cardiovascular or cerebral care are increasing. Critically ill patients with time-sensitive diseases are transported by the physician-staffed HEMS. In multiple respects, efforts have been made to enhance the system of care. For time-sensitive diseases, it is important to ensure the optimal timing for the right treatment, rapid transportation, and quick decision making. Transferred patients are often accompanied by CD/DVDs of digitally recorded images done at the referring hospital. Confirming the care provided and any imaging done at the scene or the referring hospital is essential for proper decision making. Physicians at the


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**Table 2.** The number of the digital images undergone at the referring hospital and the upload time to our PACS (ViewRex 3; Techheim, Seoul, Korea)

| Image modality | Frequency (%) | No. of images | | | Upload time (min) | | |
|---|---|---|---|---|---|---|---|
| | | Median (IQR) | Minimum | Maximum | Median (IQR) | Minimum | Maximum |
| X-ray | | | | | | | |
| Chest | 225 (70.1) | 1 (1.0–3.0) | 1 | 19 | 14 (9.0–20.0) | 1 | 83 |
| Abdomen | 73 (22.7) | 2 (1.0–2.0) | 1 | 23 | 14 (10.0–20.0) | 4 | 80 |
| Pelvis | 53 (16.5) | 1 (1.0–2.0) | 1 | 6 | 14 (9.5–20.5) | 1 | 39 |
| Head | 53 (16.5) | 4 (3.0–4.0) | 1 | 9 | 14 (9.5–23.0) | 3 | 65 |
| Cervical spine | 64 (19.9) | 3 (2.0–3.0) | 1 | 10 | 13 (9.0–17.0) | 1 | 65 |
| TL spine | 46 (14.3) | 4 (2.0–7.3) | 2 | 18 | 15 (11.8–21.3) | 5 | 82 |
| Extremity | 93 (29.0) | 6 (4.0–12.0) | 1 | 82 | 13 (10.0–18.5) | 2 | 83 |
| CT | | | | | | | |
| Brain | 167 (52.0) | 118 (84.0–165.0) | 31 | 1,042 | 12 (7.0–16.0) | 1 | 78 |
| Face | 42 (13.1) | 209.5 (167.8–296.8) | 74 | 771 | 12 (9.0–17.0) | 3 | 35 |
| Chest | 92 (28.7) | 384 (262.5–506.5) | 136 | 1,128 | 14 (7.3–26.8) | 0 | 138 |
| Abdomen | 94 (29.3) | 373 (300.3–463.3) | 124 | 1,890 | 12 (7.8–19.0) | 1 | 80 |
| Cervical spine | 37 (11.5) | 167 (126.0–194.0) | 97 | 556 | 13 (8.0–19.0) | 2 | 49 |
| TL spine | 15 (4.7) | 250 (211.0–369.0) | 88 | 645 | 20 (15.0–31.0) | 11 | 169 |
| Extremity | 22 (6.9) | 341.5 (212.3–463.8) | 158 | 1,304 | 15.5 (11.5–26.0) | 6 | 32 |
| MRI | | | | | | | |
| Brain | 19 (5.9) | 198 (84.0–260.0) | 46 | 1,171 | 16 (8.0–27.0) | 3 | 74 |
| Cervical spine | 5 (1.6) | 89 (69.5–240.5) | 67 | 379 | 13 (11.5–25.5) | 11 | 32 |
| TL spine | 15 (4.7) | 117 (84.0–237.0) | 75 | 334 | 21 (13.0–33.0) | 6 | 51 |
| Extremity | 4 (1.2) | 184.5 (130.0–1,051.3) | 115 | 1,337 | 14 (13.0–29.3) | 13 | 34 |
| Electrocardiography | 50 (15.6) | 1 (1.0–1.0) | 1 | 3 | 13 (7.8–23.3) | 4 | 76 |
| Angiography | 5 (1.6) | 1,041 (390.0–1,690.5) | 143 | 1,863 | 20 (11.5–30.5) | 9 | 40 |
| Endoscopy | 15 (4.7) | 67 (37.0–116.0) | 15 | 175 | 14 (11.0–27.0) | 9 | 68 |
| Ultrasonography | 44 (13.7) | 36.5 (16.0–264.5) | 5 | 1,837 | 16.5 (12.3–24.3) | 5 | 80 |
| Total | 321 (100) | 302 (86.0–759.5) | 1 | 4,954 | 14 (9.0–21.0) | 1 | 169 |

PACS, picture archiving and communication systems; IQR, interquartile range; TL, thoracolumbar; CT, computed tomography; MRI, magnetic resonance imaging.

**Table 3.** The number of digital images done at the referring hospital and the upload time according to disease category

| Variable | TTA (n=62) | Non-TTA trauma (n=89) | Nontrauma (n=170) | P-value |
|---|---|---|---|---|
| No. of images | | | | |
| Minimum | 1 | 2 | 1 | - |
| Maximum | 3,309 | 2,022 | 4,954 | - |
| Median (IQR) | 688 (292.0–1,117.8) | 281 (97.0–589.0) | 176 (49.5–676.0) | <0.001 |
| T[a)] | a[b)] | b, c | c | - |
| Upload time (min) | | | | |
| Minimum | 1 | 2 | 1 | - |
| Maximum | 169 | 65 | 138 | - |
| Median (IQR) | 10 (6.0–16.3) | 14 (9.0–18.0) | 15 (10.0–25.0) | 0.001 |
| T[a)] | a[b)] | b, c | c | - |
| ≤20 | 50 (80.6) | 71 (79.8) | 109 (64.1) | 0.048 |
| 21–30 | 5 (8.1) | 8 (9) | 30 (17.6) | - |
| 31–40 | 5 (8.1) | 6 (6.7) | 13 (7.6) | - |
| >40 | 2 (3.2) | 4 (4.5) | 18 (10.6) | - |

Values are presented as number or frequency (%).
TTA, trauma team activation; IQR, interquartile range.
[a)]The same letters indicate nonsignificant difference between groups based on the subgroup Mann-Whitney U-test; [b)]P<0.001.

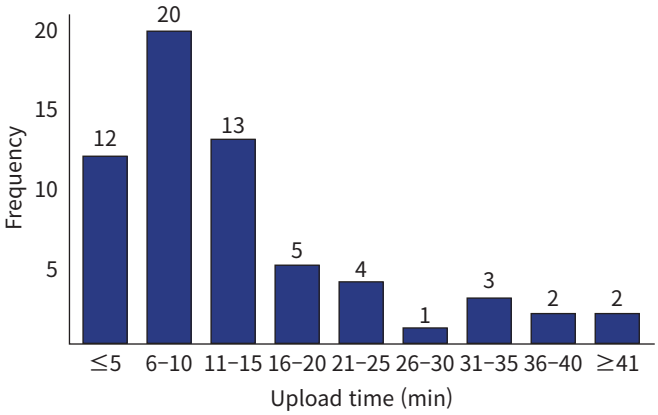


**Fig. 1.** The distribution of the upload times of outside images in trauma team activation patients.

**Table 4.** Comparison of the number of digital images and upload times between the TTA and acute stroke groups

| Variable | TTA (n=62) | Stroke (n=14) | P-value |
|---|---|---|---|
| No. of images | | | |
| Median (IQR) | 688.0 (292.0–1,117.8) | 159.5 (76.8–550.0) | 0.009 |
| Minimum | 1 | 35 | - |
| Maximum | 3,309 | 1,242 | - |
| Upload time (min) | | | |
| Median (IQR) | 10.0 (6.0–16.3) | 7.5 (4.8–12.3) | 0.123 |
| Minimum | 1 | 3 | - |
| Maximum | 169 | 27 | - |

TTA, trauma team activation; IQR, interquartile range.

receiving hospital can easily review the care provided in the medical record sent by the inter-hospital transfer communications system. However, the outside images must be viewed directly. Without the ability to review them, repetition of the same imaging studies is inevitable. Cost increase, radiation hazard, and pre-administered intravenous contrast-induced image inadequacy could occur with repetition of imaging. Moreover, if the patient is unstable, a further diagnostic/radiologic study may not be possible. Therefore, physicians must review outside images, and time is required for this process. Therefore, the upload times need to be verified.

In our study, the median number of outside images was 688 in the TTA group, which was greater than that of the non-TTA or nontrauma groups. However, the median upload time was shorter (10 minutes). In the TTA group, the upload time was shorter despite the much higher number of outside images. There is a reason for this discrepancy. When a transferred patient arrives at the ED, the accompanying CD/DVD could be reviewed directly on the ED computer before transmission to the PACS. This is not typically done by physicians treating patients with major trauma. The care of trauma patients often includes many specialists who each check the images separately. Therefore, quickly uploading the CD to the PACS is most efficient. However, for patients with other diseases, the outside CD could be reviewed on the ED computer before transmission to the PACS. This is why the upload time was shorter for the large number of images in the TTA group.

Three more key points should be made. First, regarding the definition of upload time, the images are transmitted randomly, in no particular order (such as X-ray→CT→MRI or in order of the study date). Therefore, outside images can only be read after the transmission of all images is completed. The upload time was calculated based on the last image uploaded. Therefore, a result of 10 minutes is just a theoretical time interval of the image displaying system. More time is required in reality. Even if physicians wait for images to be uploaded without doing any other work, at least 10 minutes would be required. Moreover, it is difficult to tell whether all the images on the CD have been uploaded or are still in progress in the PACS. In general, the transmission completion is not obvious until there no more images are being uploaded. After that, the physicians must read the images in detail, which takes more time. The upload times shown in this study are literally the shortest possible time, and longer times are realistically required in most clinical situations. This 10- to 20-minute time difference may not have a significant impact on patients with certain diseases, but it can have an important negative impact on time-sensitive diseases.

A second important point is that 169 minutes were taken for one patient, and image uploading took more than 20 minutes for 12 patients (Fig. 1). Taking more than 20 minutes to read the radiologic images of an unstable patient with major trauma means that outside images can be unhelpful. Because the radiologic diagnosis is essential for proper decision making, repetition of the radiologic study is inevitable if the outside images cannot be read within 20 minutes. If the patient's condition does not allow obtaining additional images, the physician has to make a decision without radiologic evidence. Unexpectedly prolonged times were observed when the CD arrived late with a patient's guardian, the CD was lost, or there was transmission error. Because such outliers exist, interpretations based only on average or median times can be skewed. In addition to delays, a focus on prolonged upload times is also necessary. The number of images may be high because past images were included, not just those done on that day. However, the receiving hospital is unable to address this; it is up to the referring hospital to separate and copy only images from the relevant day.


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A third important point is the interpretation of the relationship between the number of images and upload time, as shown in Table 2. No substantial difference was observed in the upload times based on image modality, such as X-rays with few images and CT or MRI with many images. This occurs because the images in the CD are uploaded randomly without a particular order (e.g., X-ray→CT→MRI). In addition, if the patient had a CT scan with a large number of images (e.g., 400 images), the numerous images are uploaded at the same time in our PACS, and when the CT images are uploaded, other images such as X-ray or MRI are uploaded as well. As a result, X-rays with fewer images were not necessarily uploaded quickly, and CT or MRI scans with many images were not necessarily uploaded late, but the overall upload time was longer because of the large number of images. In the same patient, the upload times appeared approximately the same regardless of the number of images, based on image modality.

In AMI patients, any paper electrocardiogram strips can be located immediately upon patient arrival and a repeat electrocardiogram can be done quickly if necessary. However, in stroke and major trauma patients, outside images were read directly from the PACS. Trauma patients often have many images. In our study, the median number of images in the TTA patient group was 688, 4.3 times that of stroke patients (Table 4), and longer upload times were observed. Both trauma and stroke are time-sensitive diseases and the outside images of patients with both trauma and stroke are directly uploaded to our PACS. Therefore, this study compared these two conditions. This finding means that longer upload times are required for higher numbers of images. Prior research showed that reading of outside images in transferred trauma patients resulted in significant delays (up to 25 minutes) [9], and that repeated CT scans increased the workload and use of resources at receiving hospitals [10].

For critical or time-sensitive diseases, efforts are required to reduce the time needed to make outside images ready for physician review and to avoid duplicate imaging. One possible option is a remote emergency consultation system for medically vulnerable areas. This is a system in which radiologic images or electrocardiograms performed at a referring hospital can be uploaded to a website and medical staff (primarily emergency physicians) at the predesignated receiving hospital can review the images and provide appropriate consultation. One study also found that this type of remote viewing by emergency consultation systems could reduce unnecessary transfers to a level I trauma center by 40% [11]. However, it assumed that the medical staff at the receiving hospital was available to review the uploaded images in advance during patient transfer, thereby minimizing the time taken after arrival.

When transporting patients with AMI using HEMS, the door-to-balloon time was reduced by 16 minutes compared to when ground transportation was used [12]. Comparing ground transportation and HEMS, the number of patients who received care within the targeted window of time increased with the use of HEMS (11.4% and 40.5%, respectively). Considering this, simply being able to check outside images in advance could replicate the time-saving effects of helicopter transfers. Another advantage of this system is minimizing the risk of lost or late CD/DVDs or transmission errors.

It may be possible to open an imported CD directly on the computer before uploading. However, if the patient has to be evaluated or treated by multidisciplinary specialists (e.g., major trauma), it is not efficient to check one CD in one ED computer, eventually leading to unnecessary duplicate images, loss of necessary images, and time delay. Therefore, patients with major trauma need a system making it possible to check outside images done at referring hospitals in advance before arrival.

This study had several limitations. Since it was a retrospective study, it was difficult to investigate the exact reasons for the significant delays in all cases, and transmission error rates during the upload were not estimated. Because this was a single-center study, it was not confirmed whether the type of PACS software or computer specifications would affect the upload time. Furthermore, the prognosis of the patients affected by delayed upload times remains unknown.

In conclusion, patients with major trauma bring more images than patients with other diseases. Unexpected delays (> 20 minutes) were noted in approximately 20% of them. It is necessary to minimize this time by actively utilizing a system that allows medical staff to view the outside images in advance before patient arrival.

## SUPPLEMENTARY MATERIALS

**Table S1.** Types of digital images done at the referring hospital according to disease category

Supplementary material is available from: https://doi.org/10.20408/jti.2021.0039.

## NOTES

### Ethical statements

Not applicable.

## Conflicts of interest

The authors have no conflicts of interest to declare.

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## Author contributions

Conceptualization: HIK, YOK; Data curation: all authors; Formal analysis: HIK; Writing–original draft: SJW, HIK; Writing–review & editing: YOK.
All authors read and approved the final manuscript.

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# The clinical pattern of intentional injuries at a primary Saudi Arabian trauma center

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**Purpose:** The term "intentional injuries" refers to a spectrum of injuries resulting from self-inflicted injuries, interpersonal violence, and group acts of violence. Intentional injuries are underreported in Saudi Arabia. This study aimed to analyze and evaluate the characteristics of intentional injuries in patients who presented to the emergency department of a primary trauma center in Medina, Saudi Arabia in 2013.

**Methods:** A prospective cohort database analysis of the clinical patterns and treatment outcomes of 252 patients who had intentional injuries between January and December 2013 was done.

**Results:** The proportion of trauma patients with intentional injuries was 1.3%. The mean age was 34.2±9.4 years, 141 patients (56.0%) were male, and 111 (44.1%) were female (male to female ratio, 1.27:1). The majority (n=159, 63.1%) of injuries occurred at night. Most occurred outside the home (n=180, 71.0%). Financial problems (n=62, 24.6%) and social disputes (n=61, 24.2%) were the most common reasons. Sharp objects (n=93, 36.9%) were the most common weapons used. The head and neck were the most commonly injured areas (n=63, 54.4%). Superficial cuts (n=87, 34.5%), were the most common type of injury. Suturing of wounds (n=54, 21.4%) and surgical debridement (n=47, 18.7%) were the most commonly performed modalities of management.

**Conclusions:** We conclude that intentional injuries in Saudi Arabia are a health care hazard that is, unfortunately, underreported. The clinical pattern is similar in most aspects to international reports but differs in certain features due to the specific religious and conservative characteristics of the community. Nationwide clinical studies are strongly recommended.

**Keywords:** Emergencies; Wounds and injuries; Saudi Arabia

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## INTRODUCTION

An injury is defined as damage to the human body resulting from unintentional or intentional exposure to an energy source (mechanical, thermal, electrical, chemical, or radiant). Another definition is the state of insufficiency of vital elements (heat, oxygen) that exceeds the threshold of physiological tolerance, resulting in impairment or destruction of health. Both intentional and unintentional injuries have become a global public health concern regarding morbidity and mortality [1].

Injuries are one of the leading causes of death and disability throughout the world in all age groups under 60 years and are estimated to cause 10% to 30% of all hospital admissions across the globe and to account for approximately 9.6% of all deaths and 16% of all disabilities, with the greatest impact in developing countries [1,2]. Approximately five million people worldwide died as a result of an injury in 2010, accounting for nearly one in every 10 deaths. Of these, more than one in four were caused by an intentional injury [2].

Intentional injuries include interpersonal violence, child maltreatment, self-inflicted harm (burn, cut, bruises), community violence, or group-instigated acts of violence, homicide, sexual abuse, and suicide. Unintentional injuries include road traffic incidents, motor vehicle-related injuries, falls, drowning, environmental injuries, sports, and recreational injuries, poisoning, and fire-related injuries/burns [1,2].

In 2002, global data on the burden of injury showed that intentional injuries accounted for 1.5% of the disability-adjusted life years (DALYs) for 5- to 14-year-old girls and 2% of boys in this age group. In a panel of adolescents and young adults (15–29 years), the representation of intentional injuries among the total DALYs was slightly lower in female patients (1.2%), but dramatically higher in male patients (8.9%) [3]. While mortality represents a significant component of this impact, it is estimated that there are 20 to 40 victims of nonfatal violence for every death [4].

Intentional injuries form a spectrum (including self-inflicted injuries, interpersonal violence, and group acts of violence) of injuries caused by purposeful human action, whether directed at oneself or others. Intentional injuries include self-inflicted and interpersonal acts of violence intended to cause harm. They are very common and contribute significantly to morbidity and mortality and are reported to cause about nine deaths for every 100,000 persons, most of whom are economically productive individuals in the age range of 15 to 45 years. The reported significant risk factors for intentional injuries from interpersonal or self-inflicted violence include access to firearms, history of interpersonal violence, history of alcohol and drug abuse, mental illness, and poverty [5].

National, regional, cultural, and religious characteristics could influence the risk of intentional injuries, but the environmental factors that lead to injuries are often associated with other environmental health hazards. The diagnosis and recording of intentional injuries are problematic because intent could be difficult to assess, which led the World Health Organization to highlight two important points. The first is that the use of force does not necessarily correlate with the intent to damage. The second is that there may be differences in the intent to injure and the intent to use forms of violence that might be culturally acceptable in some settings [6].

Intentional injuries, which have been reported to represent a generally neglected, but growing epidemic in many developing countries, contribute substantially to the global injury burden, constitute a threat to the physical and psychological state of well-being of the victims, and are associated with substantial emotional and financial burdens on the community, family, and hospital resources [7]. The problem was found to be increasing at a fast rate in developing countries due to increasing conflicts over limited resources, unemployment, easy access to firearms, drug/alcohol abuse, substance misuse, and increased crime rates [8].

The socioeconomic impact of intentional injuries has received considerable attention due to the loss of productive years and the exhaustion of limited health care funds. Scientific studies and official reports have shown that the victims of intentional injuries constitute a socially and economically disadvantaged population because their medical care is poorly funded [9].

The 2010 Global Burden of Disease study indicated that intentional self-inflicted injuries rose by 23.8% between 1990 and 2010 in all ages [10]. Several studies in Saudi Arabia have documented the incidence and etiology of unintentional injuries, and trauma in general, using surveillance data, but no study has yet described the incidence, features, or outcomes of intentional injuries. There is a paucity of sufficient information in most developing countries regarding the morbidity and mortality of intentional injuries, as more concerns have been focused on the more common injuries related to road traffic and motor vehicle accidents at the expense of the less common category of self-inflicted injuries [11–14].

The purpose of this study was to evaluate and analyze the characteristics of intentional injuries in patients who presented to the emergency department of Al Ansar General Hospital, a primary trauma center in Medina, Saudi Arabia (ranked number 1 emergency center nationwide receiving emergency cases through


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2012–2014), and to document the clinical patterns and outcomes of these intentional injuries.

## METHODS

Ethical approval was granted from the Ethical Committee of Al Ansar General Hospital, Medina, Saudi Arabia and the management guidelines and clinical pathway subcommittee of the quality care program at the same hospital. A prospective cohort database analysis was conducted of the clinical patterns and treatment outcomes of Saudi Arabian patients involved in intentional injuries during the 12-month period between January and December 2013. Informed consent was obtained from all individual participants included in this study. The study protocol was designed using a digital database file in the outpatient department as part of the quality care program at Al Ansar General Hospital, Medina, Saudi Arabia.

All patients presented to the emergency department of the public health general hospital in Medina, Saudi Arabia. They were managed according to the Advanced Trauma Life Support protocol. The assessment of injuries, initial resuscitation, diagnostic workup, medical and supportive management, surgical procedures, and follow-up were carried out by the same surgical team with the participation of the emergency department staff. The patients were classified according to the modalities of treatment as receiving observation, resuscitation, medical care, and minor or major surgical intervention.

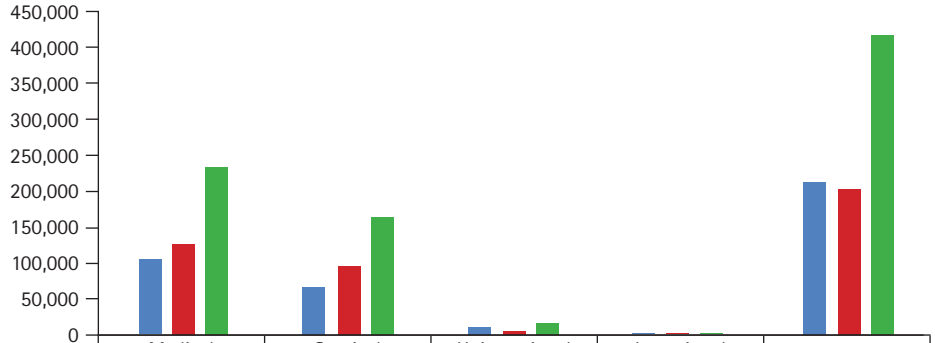
Data on patients' management and treatment outcomes were collected and analyzed. The digital database study records were reviewed and analyzed for factors such as age, sex, sociodemographic data, reason for the injury, type of weapon, site of injury, type of injury, the modality of management, and the outcome. Results were presented as absolute frequencies, percentages, and mean values. IBM SPSS ver. 22 (IBM Corp., Armonk, NY, USA) was used for data analysis.

## RESULTS

In total, 252 Saudi Arabian patients involved in intentional injuries were included. In the same period, the overall total number of emergency cases seen and treated in the emergency department of our hospital was 418,076 patients. Among them, 19,364 patients were diagnosed and treated for all forms of trauma. The proportion of trauma cases among emergency patients at our hospital in 2013 was 4.6%. The proportion of intentional injuries among emergency patients in our hospital in 2013 was 0.1%, and the proportion of intentional injuries among trauma patients at our hospital in 2013 was 1.3% (Fig. 1).

The mean age was 34.2 ± 9.4 years (range, 13–57 years). The most common age group was 30 to 40 years (57.9%), followed by 20 to 29 years (32.5%), and 41 to 50 years (4.4%), respectively. An analysis of the distribution of patients by sex showed that 141 patients (56.0%) were male and 111 (44.1%) were female (male to female ratio, 1.27:1). The majority of patients (81.0%) had a formal education, while 16% had a nonformal education and 3% were illiterate. Most patients (n = 140, 55.6%) were married, 104 (41.2%) were single, and only eight (3.2%) were divorced. In women, married status showed a significant relationship with intentional injuries ($P < 0.05$).

Although our hospital is a regional trauma primary center, the majority of intentional injury patients were from the city of Medina (n = 222, 88.1%), followed by towns and villages (n = 23,




| | Medical diseases | Surgical diseases | Unintentional injury | Intentional injury | Total |
|---|---|---|---|---|---|
| Male | 106,187 | 67,899 | 12,607 | 141 | 213,597 |
| Female | 128,307 | 96,319 | 6,505 | 111 | 204,479 |
| Total | 234,494 | 164,218 | 19,112 | 252 | 418,076 |

**Fig. 1.** The overall total number of emergency cases seen at Al Ansar General Hospital, Medina, Saudi Arabia during 2013.

9.1%), and rural areas (n = 7, 2.8%). The majority of intentional injuries (n = 159, 63.1%), occurred at night. Married status showed a statistically significant relationship with night-time intentional injuries (P < 0.05). Most of the intentional injuries (n = 180, 71.0%), occurred outside the home. Married status showed a statistically significant relationship with outside intentional injuries (P < 0.05) (Table 1).

Men were more likely to have night-time injuries (83.0%) and injuries occurring outside the home setting (85.0%) than women, which represented a statistically significant difference (P < 0.05) (Fig. 2).

Regarding the reasons for intentional injury, financial problems (n = 62, 24.6%) and social disputes (n = 61, 24.2%) were the most common. All reasons showed statistically significant relationships (P < 0.05) with the male sex, except for sexuality, which had a statistically significant relationship (P < 0.05) with the female sex (Table 2).

Concerning the weapons used in intentional injuries, sharp

**Table 1.** Sociodemographic data of intentional injuries in Saudi Arabian patients

| Characteristic | Total | Marital status | | |
|---|---|---|---|---|
| | | Single | Married | Divorced |
| Sex | | | | |
| Male | 141 (56.0) | 72 (51.0) | 63 (44.7) | 6 (4.3) |
| Female | 111 (44.0) | 32 (28.8) | 77 (69.4) | 2 (1.8) |
| Total | 252 (100) | 104 (41.2) | 140 (55.6) | 8 (3.2) |
| Demographic data | | | | |
| Madinah city | 222 (88.1) | 102 (45.9) | 115 (51.8) | 5 (2.3) |
| Towns and villages | 23 (9.1) | 6 (26.1) | 14 (60.9) | 3 (13.0) |
| Rural areas | 7 (2.8) | 4 (57.14) | 3 (42.7) | 0 |
| Total | 252 (100) | 112 (44.4) | 132 (52.4) | 8 (3.2) |
| Time | | | | |
| Day | 93 (36.9) | 41 (44.1) | 48 (51.6) | 4 (4.3) |
| Night | 159 (63.1) | 47 (29.6) | 108 (67.9) | 4 (2.5) |
| Total | 252 (100) | 88 (34.9) | 156 (61.9) | 8 (3.2) |
| Setting of intentional injury | | | | |
| Inside home | 72 (29.0) | 39 (54.2) | 26 (36.1) | 7 (9.7) |
| Outside home | 180 (71.0) | 46 (25.6) | 133 (73.8) | 1 (0.6) |
| Total | 252 (100) | 85 (33.7) | 159 (63.1) | 8 (3.2) |

Values are presented as number (%).

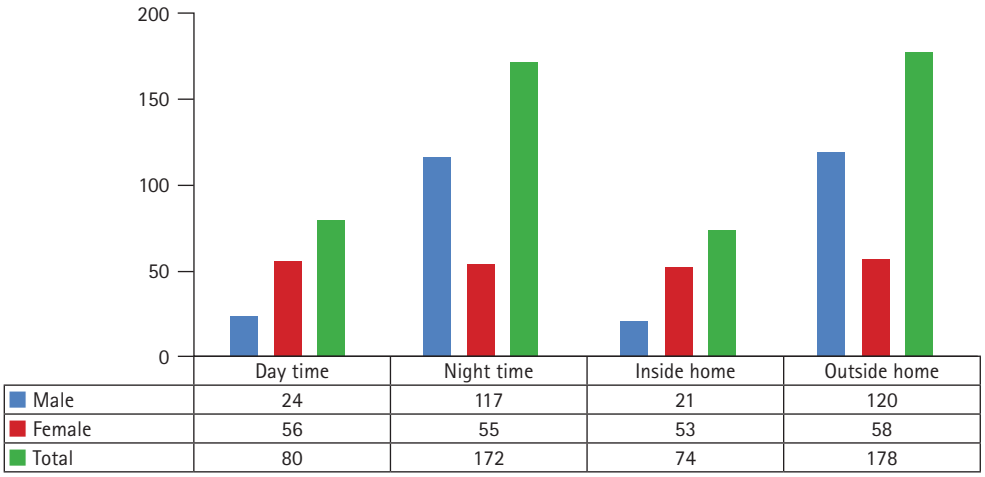



**Fig. 2.** Comparison of the time and setting of intentional injuries in Saudi Arabian patients by sex.


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**Table 2.** The distribution of reasons of injury according to sex among Saudi Arabian patients with intentional injuries

| Reason | No. (%) | Ratio (male:female) |
|---|---|---|
| Religious | 10 (4.0) | 70:30 |
| Suicidal | 19 (7.5) | 79:21 |
| Drugs and alcohol | 31 (12.3) | 65:35 |
| Social disputes | 61 (24.2) | 82:18 |
| Psychological | 43 (17.1) | 61:39 |
| Sexuality | 26 (10.3) | 36:64 |
| Financial problems | 62 (24.6) | 68:32 |
| Total | 252 (100) | 62:38 |

objects (n = 93, 36.9%) were the most common. All weapons showed statistically significant relationships (P < 0.05) with the male sex, except for body parts (mainly punching by a fist), which was significantly associated (P < 0.05) with the female sex (Table 3).

An analysis of the body parts injured showed that the head and neck were the most commonly injured (n = 63, 54.4%), followed by the abdomen (n = 41, 12.3%). Injuries to the upper limbs showed a statistically significant relationship (P < 0.05) with the male sex, while injuries of the genitalia showed a statistically significant relationship (P < 0.05) with the female sex (Table 4).

Superficial cuts (n = 87, 34.5%), were the most common type of injury, and they were found to have a statistically significant relationship (P < 0.05) with the male sex. Blunt injuries showed a statistically significant relationship (P < 0.05) with the female sex (Table 5).

Suturing of wounds (n = 54, 21.4%) and surgical debridement (n = 47, 18.7%) were the most commonly performed modalities of management in both male and female patients. Major surgical interventions, cardiopulmonary resuscitation, and fracture treatment showed a statistically significant relationship (P < 0.05) with the male sex (Table 6).

A total of 205 patients (81.3%) were treated and discharged, 17 (6.7%) developed a chronic illness, 14 (5.6%) had permanent disabilities, and 14 (5.6%) died (Fig. 3). The majority of patients (n = 234, 92.9%), completed their treatment at our hospital, while 18 (7.1%) were resuscitated and transferred to a specialized tertiary hospital for advanced therapies (Fig. 4). An analysis of the mode of transportation showed that 172 patients (68.3%) were brought by ambulance (the Saudi Red Crescent organization), 33 (13.1%) by their parents, 27 (10.7%) by relatives, 11 (4.4%) by neighbors, and nine (3.6%) by themselves (Fig. 5).

**Table 3.** The relationship between the weapons used and the sex of Saudi Arabian patients with intentional injuries

| Weapon | No. (%) (n=252) | Sex (%) | |
|---|---|---|---|
| | | Male (n=141) | Female (n=111) |
| Glasses | 18 (7.1) | 10 (55.6) | 8 (44.4) |
| Sharp objects | 93 (36.9) | 61 (65.6) | 32 (34.4) |
| Metal bars | 11 (4.8) | 7 (63.6) | 4 (36.4) |
| Wood sticks | 27 (10.7) | 18 (66.7) | 9 (33.3) |
| Ropes | 9 (3.6) | 4 (44.4) | 5 (55.6) |
| Poisons | 13 (5.2) | 6 (46.2) | 7 (53.9) |
| Guns | 25 (9.9) | 19 (76.0) | 6 (24.0) |
| Body parts | 49 (19.4) | 14 (28.6) | 35 (71.4) |
| Fire | 7 (2.8) | 2 (28.6) | 5 (71.4) |

**Table 4.** The relationship between the body parts injured and the sex of Saudi Arabian patients with intentional injuries

| Body part | No. (%) (n=252) | Sex (%) | |
|---|---|---|---|
| | | Male (n=141) | Female (n=111) |
| Head and neck | 63 (54.4) | 32 (50.8) | 31 (49.2) |
| Upper limbs | 29 (7.5) | 19 (65.5) | 10 (34.5) |
| Lower limbs | 34 (4.0) | 20 (52.8) | 14 (41.2) |
| Chest | 26 (8.3) | 14 (53.9) | 12 (46.2) |
| Abdomen | 41 (12.3) | 24 (58.5) | 17 (41.5) |
| Back/spine | 23 (3.2) | 11 (47.8) | 12 (52.2) |
| Genitalia | 17 (10.3) | 12 (70.6) | 5 (29.4) |
| Pelvis | 19 (7.5) | 8 (42.1) | 11 (57.9) |

**Table 5.** The relationship between the type of injury and the sex of Saudi Arabian patients with intentional injuries

| Type of injury | No. (%) (n=252) | Sex (%) | |
|---|---|---|---|
| | | Male (n=141) | Female (n=111) |
| Superficial cuts | 87 (34.5) | 62 (69.1) | 25 (30.9) |
| Lacerations | 21 (8.3) | 9 (46.2) | 12 (53.8) |
| Blunt | 43 (17.1) | 10 (23.3) | 33 (76.7) |
| Penetrating | 31 (12.3) | 17 (54.8) | 14 (45.2) |
| Strangulation | 12 (5.6) | 7 (57.1) | 5 (42.9) |
| Amputation | 2 (0.8) | 2 (100) | 0 |
| Fracture | 36 (14.3) | 23 (63.9) | 13 (36.1) |
| Burns | 7 (2.8) | 4 (57.1) | 3 (42.9) |
| Toxic reactions | 13 (5.2) | 5 (38.5) | 8 (61.5) |

## DISCUSSION

From 2012 to 2014, Al Ansar General Hospital, a primary trauma center in Medina, Saudi Arabia, was ranked the top emergency medical center nationwide. In 2013, it received a total of 418,076 patients as emergency cases. As a consequence, a large amount of

**Table 6.** The relationship between the type of management and the sex of Saudi Arabian patients with intentional injuries

| Management | No. of patients (%) (n=252) | Sex (%) | |
|---|---|---|---|
| | | Male (n=141) | Female (n=111) |
| Observation | 17 (6.7) | 12 (70.6) | 5 (29.4) |
| Antidotes and lavage | 8 (3.2) | 3 (37.5) | 5 (71.4) |
| CPR and resuscitation | 12 (4.8) | 9 (75.0) | 3 (25.0) |
| Debridement | 47 (18.7) | 22 (46.8) | 25 (53.2) |
| Suturing | 54 (21.4) | 28 (51.9) | 26 (48.1) |
| Burn wounds care | 7 (2.8) | 4 (57.1) | 3 (42.9) |
| Fracture treatment | 36 (14.3) | 23 (63.9) | 13 (36.1) |
| Minor surgical intervention | 28 (11.1) | 18 (64.3) | 10 (35.7) |
| Major surgical intervention | 33 (13.1) | 22 (66.7) | 11 (33.3) |

CPR, cardiopulmonary resuscitation.

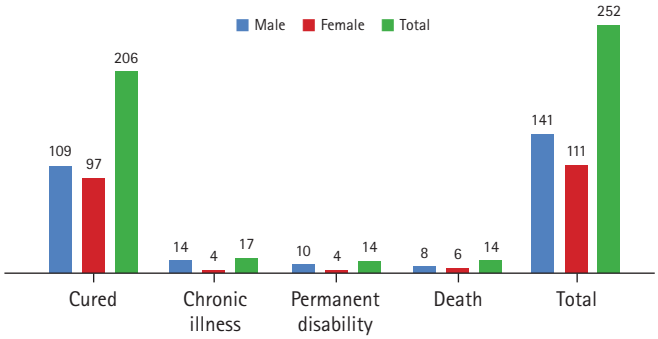



**Fig. 3.** The outcomes of treatment of intentional injuries in Saudi Arabian patients.

data was analyzed by several research groups, and we were assigned to investigate trauma patients. This assignment resulted in 11 audit reports, of which this paper is the first product of 18 drafted clinical studies. The amount of clinical data regarding intentional injuries that were retrieved was too vast to be included in a single study, so we had to split it into three separate papers with different kinds of analyzed data.

In our study, the most common age group involved in intentional injuries was 30 to 40 years, which accounted for 57.9% of all patients. Male patients were 1.27 times more common than female, which is similar to the ratios reported by many interna-

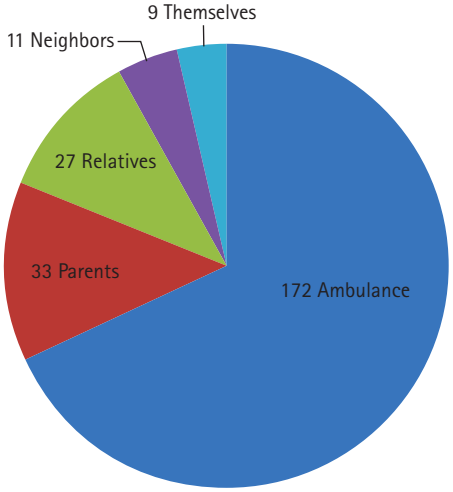
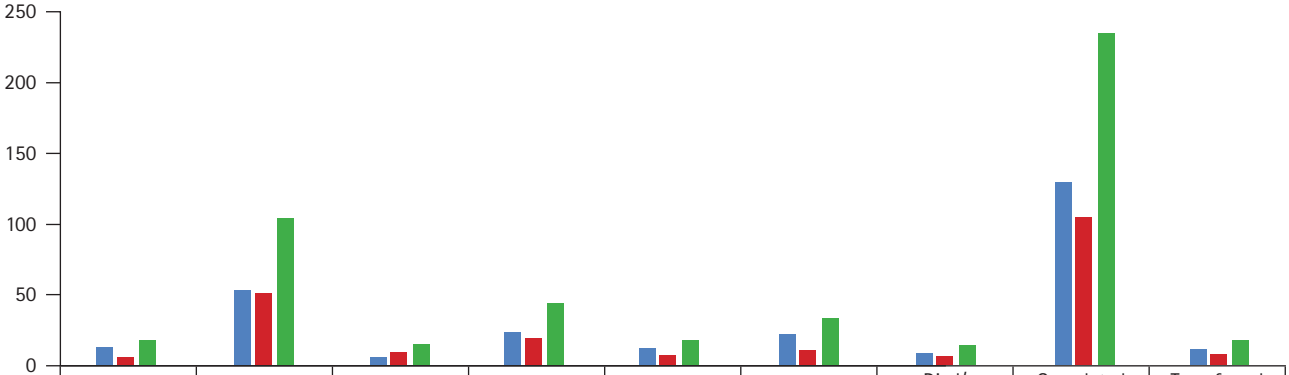



**Fig. 5.** The mode of transportation of Saudi Arabian patients with intentional injuries.




| | Oservation and discharged | Treated in ER and discharged | Discharged against advice | Admitted to inpatient ward | Admitted to ICU | Transferred to operating room | Died/ transferred to mourge | Completed treatment in our hospital | Transferred to a tertiay hospital |
|---|---|---|---|---|---|---|---|---|---|
| Male | 12 | 53 | 5 | 24 | 12 | 22 | 8 | 130 | 11 |
| Female | 5 | 51 | 9 | 19 | 6 | 11 | 6 | 104 | 7 |
| Total | 17 | 104 | 14 | 43 | 18 | 33 | 14 | 234 | 18 |

**Fig. 4.** The outcomes of the management of Saudi Arabian patients with intentional injuries. ER, emergency room; ICU, intensive care unit.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tional published reports [15]. An analysis of the setting of intentional injuries showed that 71% of the cases happened outside the home environment, with male patients being more affected (about 67.4%) than female patients (about 32.6%). This discrepancy could be explained by the social and religious characteristics of Saudi Arabian society, in which men are disproportionately represented in activities outside the house, while women tend to remain at home.

An analysis of the timing of intentional injuries showed that the majority of intentional injuries (n = 159, 63.1%), occurred at night. In combination with the finding that 71% of intentional injuries occurred outside the home environment, this finding logically represents aspects of the lifestyle in Saudi Arabia, in which the severely hot daytime weather leads to most social activities (indoor or outdoor) being conducted at night, outside of official working and school hours. Surprisingly, some studies from parts of the world with a cool or moderate climate also reported similar patterns in terms of the majority of injuries occurring outside the home and at night [16].

We observed that the male sex was a risk factor for intentional injuries regarding the timing, setting, reasons for the injury (except sexuality), body parts injured (except genitalia), and the weapons used (except body parts). This finding is logical, since Saudi Arabian society is male-dominant, but it is worth mentioning that the conservative character of Saudi Arabian society could influence the results because women usually fear social scandal and possible punishment or retaliation from their parents (if single) or husbands (if married).

Several international studies reported that a significant number of patients treated for intentional injuries had a history of previous intentional injury or attempts. For instance, Goins et al. [17] reported that in 72 patients, 49% had a previous episode of intentional injury. Poole et al. [18] reported that 61% of 64 patients had a previous episode. Sims et al. [19] reported that 44% of 263 patients sustained another episode of intentional injury within 5 subsequent years. In our study, 49 patients (19.4%) with intentional injuries reported a history of a previous occurrence or attempt of intentional injury, which supports the possibility that the victims of intentional injury are at high risk for future injury.

In contrast to most previously published studies [1–19], financial problems (n = 62, 24.6%) and social disputes (n = 61, 24.2%) were the most common reasons for intentional injuries in this Saudi Arabian study. The psychological factors underlying these two reasons played a crucial role in the different manifestations of the recorded intentional injuries.

Many research articles have documented a religious impact on adult health-related behaviors and injuries, emphasizing the change from biomedical to psychosocial causes of sickness and death. The researchers found that religion (in its social, environmental, and behavioral forms) appeared to have an impact on health status. A literature review revealed more than 300 scientific studies documenting an association between religion and physical health effects, which has been reported in many sociodemographic groups [20]. In our study, religious reasons for intentional injuries accounted for 4.0%, with a male predominance (70.0%). Although Saudi Arabian society is considered to be conservative and religious, psychological factors again appeared as the main influencing factor (e.g., one patient self-amputated his penis because he used to get an erection when seeing women in the holy mosque [Islamic shrine] at prayer times).

It is well-established scientifically that alcohol and drug abuse is a critical health behavior associated with injuries and death, being responsible for about 120,000 deaths per year, which makes it a key predictor of various forms of injuries and illnesses [21]. Despite the religious and conservative characteristics of Saudi Arabian society which completely forbids alcohol and recreational drugs, they were responsible for intentional injuries in 31 patients (12.3%). This threat has recently gained attention as a potential hazard in Saudi Arabia [22].

Self-poisoning and chemical exposure are two growing problems worldwide that are responsible for a significant proportion of intentional injuries and are estimated to account for 23% of all the self-inflicted injuries globally. The poisons used for deliberate self-poisoning include pesticides, medicines, and rodent poisons. Chemical substances are mostly cleaning detergents [23]. Only 13 cases (5.2%) were recorded in our series in association with deliberate poisoning, a much lower value than has been reported internationally.

Firearms contribute to the majority of homicide and suicide deaths worldwide. Several clinical reports identified firearms and other weapons as potential behavioral risk factors for intentional injury in the form of fighting and suicide attempts [24]. In our study, guns were responsible for intentional injuries in 25 patients (9.9%) while sharp objects (knives, swords, and blades) were reported in 93 (36.9%), despite strict regulations and an embargo against weapons sales and acquisitions in Saudi Arabia.

Most of the patients in our study sustained soft tissue injuries and long bone fractures. The nature and type of injuries often help in understanding the kind of weapon used, which is crucial for medicolegal purposes and surgical treatment [25]. The majority of intentional injuries in our study required surgical intervention, mainly in the form of suturing (n = 28, 51.9%), debride-

ment (n = 22, 46.8%), fracture treatment (n = 23, 63.9%), minor surgical procedures (n = 18, 64.3%), and major surgical procedures (n = 22, 66.7%), demonstrating the cost and financial impact of dealing with intentional injuries.

The outcomes of the treatment of intentional injuries in Saudi Arabian patients showed that the majority (n = 206, 81.7%) were cured, while the mortality rate was 5.6%. Of the 14 dead patients, seven were suicidal, four were gunshot victims, two were self-poisoned, and two were self-burn victims. All these data and results were recorded for 1 year only. They do not represent a full picture of intentional injuries in Saudi Arabia but could provide an overview of clinical patterns in the local community. Unfortunately, this paper is the only study to report intentional injuries from a Saudi Arabian health care facility, as evident from a thorough literature search. More detailed, scientifically structured, and nationwide organized clinical studies are highly recommended.

We conclude that intentional injuries in Saudi Arabian society are a health care hazard that is, unfortunately, underreported. The clinical pattern is similar in most aspects to those that have been internationally reported but differs in certain features due to the specific religious and conservative characteristics of Saudi Arabian society. Nationwide clinical studies are strongly recommended.

## NOTES

### Ethical statements

Ethical approval was granted from the the Ethical Committee of Al Ansar General Hospital, Medina, Saudi Arabia and the management guidelines and clinical pathway subcommittee of the quality care program at the same hospital. Informed consent was obtained from all individual participants included in this study.

### Conflicts of interest

The authors have no conflicts of interest to declare.

### Funding

None.

### Author contributions

Conceptualization: HAS; Data curation: HAS; Formal analysis: HAS, AWA; Methodology: BHS; Project administration: IAZ; Visualization: BHS, IAZ, OAS, WAA, MHA, WNA; Writing–original draft: BHS, HAS; Writing–review & editing: OAS, AWA, WAA, MHA, WNA.

All authors read and approved the final manuscript.

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# Changes in patterns of plastic surgery emergencies at a level I trauma center in India during the COVID-19 pandemic

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**Purpose:** The coronavirus disease 2019 (COVID-19) pandemic has had major effects worldwide, including sudden and forceful setbacks to the healthcare system. The COVID-19 pandemic has also led to changes in the plastic and reconstructive management of emergency cases, including those due to road traffic accidents. This study analyzed changes in patterns of plastic surgery emergencies and modifications in consultation policies to minimize the exposure of healthcare workers.

**Methods:** Data on plastic surgery emergency calls received from the trauma and emergency department were collected for a period of 2 months before and during lockdown. The data were then analyzed with respect to the cause, mechanism, and site of the injury, as well as other variables.

**Results:** During lockdown, there was a 40.4% overall decrease in the plastic surgery emergency case volume (168 vs. 100). The average daily number of consultations before lockdown was 2.8 as compared to 1.6 during lockdown. Road traffic accidents remained the most common mechanism of injury in both groups (45.8% vs. 39.0%) but decreased in number during the lockdown (77 vs. 39). Household accidents, including burns, were the second most common cause of injury in both phases (7.7% vs. 20.0%), but their proportion increased significantly from 7.7.% to 20.0% in the lockdown phase (P=0.003). The percentage of minor procedures done in the emergency department increased from 53.5% to 72.0% during lockdown (P=0.002). Procedures in the operating room decreased by 73.1% during lockdown (67 vs. 18, P=0.001).

**Conclusions:** The COVID-19 pandemic and lockdown orders in India greatly influenced trends in traumatic emergencies as observed by the plastic surgery team at our tertiary care center. Amidst all the chaos and limitations of the pandemic period, providing safe and prompt care to the patients presenting to the emergency room was our foremost priority.

**Keywords:** Wounds and injuries; Plastic; Surgery; Emergencies

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## INTRODUCTION

The World Health Organization declared coronavirus disease 2019 (COVID-19) to be a pandemic on March 11, 2020. On March 22, 2020, the Government of India under Prime Minister Shri Narendra Modi ordered the "Janta curfew" and later a nationwide lockdown for 21 days, limiting movement of the entire 1.3 billion population of the nation as a preventive measure against the COVID-19 pandemic in India [1]. The first phase of the lockdown order was implemented from March 23 to April 14, and the lockdown was then continued for three more phases till May 31. The aim of the lockdown was to strictly control the movement of people to prevent the spread of infection, while simultaneously preparing the infrastructure, resources, and personnel of the healthcare system to gear up to handle the upcoming disaster. All transport services—road, air, and rail—were suspended, with exceptions for transportation of essential goods, fire, police, and emergency services [2]. Educational institutions, industrial establishments, and hospitality services were also suspended [2]. All public places, including places of worship, parks, malls, and nonessential businesses, were closed. Sports events (national and international), trains, bus locomotion, and flight services were stopped for the first and second phases of the lockdown. There were major changes in people's lifestyles and attitudes. Staying inside the home and the closure of major markets and transport led to a dramatic decrease in the number of vehicles seen on roads, which in turn led to a major decrease in road traffic accidents as reported by the media. However, every advantage has its own disadvantages as well. Staying indoors during the lockdown period made people susceptible to an increased frequency of household accidents and even domestic violence, especially during third and fourth lockdowns when liquor shops were opened. This aspect of COVID-19 has been well documented by media in periodic reports [3,4].

In the context of changes in the healthcare system and patient management policies, all hospitals—both public and private—changed their priorities. At All India Institute of Medical Sciences, Patna, India, all elective surgical procedures were postponed, and stable patients were immediately discharged to create more space for COVID-19 patients, including both suspected and confirmed cases. Initially, 200 beds were reserved for COVID-19 patients, with 30 beds for intensive care unit services. Later, seeing a sudden surge in cases in Bihar (the state where our institution is located), the government declared our institution as a dedicated COVID-19 hospital. To achieve the goals of a dedicated COVID-19 hospital, the number of COVID-19 beds was increased to 600 along with 80 intensive care unit beds, and two operating rooms were dedicated to COVID-19-related surgery. All non-COVID-19 services were stopped and only patients with positive COVID-19 tests were admitted. These measures were expedited due to the rapid influx of cases after students and migrant laborers were brought back to the state during the relaxation of the first lockdown (lockdown 1.0). Another reason for this step was to utilize the limited resources of the institution, including personal protective equipment (PPE), lab services, and personnel for COVID-19 care and to prevent unnecessary exposure to healthcare workers.

Just after the lockdown orders were issued, Department of Burns and Plastic Surgery became concerned about the impact of COVID-19 on the pattern and density of trauma cases, since plastic surgery is an integral part of trauma centers. The aim of this study was to document changing trends in injuries requiring plastic surgery consultation during lockdown, our departmental policies for managing those cases, and the efforts taken to minimize the risk of exposure to our team members.

## METHODS

The study was approved by the Institutional Review Board of All India Institute of Medical Sciences (No. AIIMS/Pat/IEC/2020/564) and performed in accordance with the principles of the Declaration of Helsinki. Since it was a retrospective study, telephonic informed consent was obtained from the patients. This retrospective study encompassed two periods (2 months each), from January 23 to March 22 (prelockdown) and from March 23 to May 22, 2020 (postlockdown). The hospital information system records and the plastic surgery duty register maintained by residents and signed by faculty on a daily basis were browsed, and data were collected. Details of patients' demographic and clinical profile including age, sex, time of injury, the time of presentation, and the cause, mechanism, and site of the injury were recorded. Comparisons were then made in relation to the time of presentation, the cause of the injury, the nature of the injury, the location of the injury, the time lag between call and consultation, the number of minor procedures and surgical interventions done (if required), and the length of hospital stay. Data were recorded under three broad headings: the pattern of emergency presentations, the mechanism of the injury, and the procedures performed. The chi-square test was used for statistical analyses, and P-values $<0.05$ were considered to indicate statistical significance.

Anticipating a decrease in the number of trauma cases due to

the nationwide lockdown and in light of the prevailing COVID-19 pandemic, the duty roster of the faculty and residents from all specialties was modified in order to prevent exposure to all of them simultaneously. At our institution, teleconsultation services were provided on a regular basis, and this policy was reinforced after issuance of the lockdown order. Following the institutional protocol, the plastic surgery department prepared a three-team roster with each team comprising one faculty member and one resident. The first team was put on emergency duty, the second team was engaged in COVID-19 duties, and the third team was kept in quarantine. Each team worked continuously for 7 days, and the roster was repeated in this sequence on a weekly basis. The quarantine team was also supposed to be used as a backup pool in case a member of the first two teams became infected and a replacement was needed. Digital communications were mostly used whenever necessary. If the resident on duty assessed the injury, then the case was discussed with a faculty member either by telephone or using WhatsApp, rather than having the faculty seeing the case in person for a second time and vice versa. This protocol was followed to minimize unnecessary exposure. If a patient required a minor plastic surgery intervention for his or her injury, it was done in the same setting with the help of other available residents and staff on emergency duty so as to avoid transferring patient and to minimize the use of PPE, which was in limited supply during the lockdown as compared to the current scenario. Standard precautions were followed in the emergency department, as no prior reverse transcriptase-polymerase chain reaction (RT-PCR) testing was done. Only patients with severe injuries were taken directly to the operating room and a surgical intervention was done under general anesthesia with all appropriate precautions, including the strict use of PPE, face shields, and judicious usage of electrocautery in combination with a smoke evacuator. Efforts were made to minimize the usage of power-driven drills and motorized instruments. An operating microscope was preferred for magnification instead of surgical loupes to avoid fogging. In the postoperative period, the patient was shifted to the area for suspected COVID-19 cases and a nasopharyngeal sample was sent as soon as possible. If the surgical intervention was nonurgent, then all efforts were made to have RT-PCR testing done before the patient was taken for surgery. According to the status of the report, the patient was either managed in a non-COVID-19 area or in the COVID-19-positive ward. In the COVID-19-positive area, if a plastic surgery consultation was required for any patient with a bedsore, cellulitis, or ulcer, it was duly attended by the COVID-19 care plastic surgery team. During the lockdown period, the plastic surgery team also managed one of the 30-bed COVID-19 wards.

## RESULTS

A total of 268 calls were received between January 23 and May 22, 2020. The number of cases between January 23 and March 22 (i.e., before lockdown) was 168. From March 23 to May 22, after implementation of the lockdown, the number was 100. The overall decrease in the case volume was 40.4%. The average number of daily consultations before lockdown was 2.8, whereas it was 1.6 during lockdown. The average age of patients before lockdown was 34.0 ± 6.2 years, as compared to 29.0 ± 4.6 years during

**Table 1.** Distribution of emergency consultations before and during lockdown

| Variable | Prelockdown[a)] (n=168) | Postlockdown[b)] (n=100) |
|---|---|---|
| Age (yr) | 34.0±6.2 | 29.0±4.6 |
| Sex | | |
| Male | 136 (80.9) | 79 (79.0) |
| Female | 32 (19.1) | 21 (21.0) |
| No. of emergency consultations | 168 (62.7) | 100 (37.3) |
| Average daily consultation | 2.8 | 1.6 |
| Time lag between call and consultation (min) | 12.3±2.8 (10–15) | 38.2±6.7 (30–45) |
| Total admissions | 67 (39.8) | 18 (18.0) |
| Duration of hospital stay (day) | 8.4±2.3 | 14.6±3.4 |
| Injury | | |
| Hand | 74 (44.0) | 43 (43.0) |
| Facial | 40 (23.8) | 25 (25.0) |
| Other | 54 (32.1) | 32 (31.0) |

Values are presented as mean±standard deviation, number (%), number only, or mean±standard deviation (range).
[a)]23 January–22 March, 2020; [b)]23 March–22 May, 2020.


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lockdown. There was no statistical difference in the distribution of patients by sex between the groups (P = 0.69). The number of emergency admissions significantly decreased from 67 to 18 (P = 0.001) (Table 1). There was no significant change in the proportion of patients who presented with hand injuries (44.0% vs. 43.0%) or facial injuries (23.8% vs. 25.0%) between the two phases (P = 0.86 and P = 0.82, respectively). The average time from receiving the telephone call on the plastic surgery helpline number and attending the consultation increased during the lockdown period (10–15 minutes prelockdown vs. 30–45 minutes postlockdown). The reasons cited by most residents were the time taken to get the PPE issued and the distance between the PPE donning area and the patient reception area.

The causes and mechanism of injuries during both periods were also analyzed, as shown in Table 2. Road traffic accidents remained the most common mechanism of injury in both groups (45.8% vs. 39.0%) but decreased in number during the lockdown (77 vs. 39). Household accidents, including burns, were the second most common cause of injury in both phases (7.7% vs. 20.0%), and their proportion increased significantly in the lockdown phase (P = 0.003). Self-inflicted injuries accounted for more cases as a percentage of all cases during lockdown (6.5% vs. 12.0%). Assault (1.7% vs. 6.0%) and gunshot injuries (2.3% vs. 7.0%) were the other common causes that showed an increasing trend during lockdown (P = 0.007). Cases due to falls from height almost doubled in percentage after issuance of the lockdown (4.1% vs. 9.0%). None of the cases reported during lockdown were due to domestic violence. No sports-related injuries were encountered in the lockdown period, and there were no reports of injuries at school. Cases of hand infection like paronychia, cellulitis, and nonhealing ulcers presenting to the emergency department during lockdown decreased significantly (P = 0.014). Other causes included dog bites, crush injuries, and lacerations.

Prior to lockdown, our team always tried to attend every case in the emergency department requiring a plastic surgery consultation, but this pattern was modified during lockdown to avoid unnecessary exposure. Thus, the percentage of patients seen physically in the emergency department decreased from 97.6% to 62.0%. Many consultations were done through telephonic conversation with on-duty residents from the trauma team. In order to restrict the movement of patients and minimize the exposure of additional healthcare workers, the majority of minor procedures (e.g., suturing of lacerations, fracture reductions, and incision and drainage) were performed in the emergency procedure room of the trauma center. This led to a

**Table 2.** Mechanism of injuries in 2-month periods before and during lockdown

| Variable | Prelockdown[a)] (n=168) | Postlockdown[b)] (n=100) | P-value[c)] |
|---|---|---|---|
| Road traffic accident | | | |
| Fall from bike | 22 (13.1) | 15 (15.0) | 0.661 |
| Collision | 55 (32.7) | 24 (24.0) | 0.129 |
| Fall from height | 7 (4.1) | 9 (9.0) | 0.106 |
| Assault | 3 (1.7) | 6 (6.0) | 0.064 |
| Gunshot | 4 (2.3) | 7 (7.0) | 0.130 |
| Self-inflicted injuries | 11 (6.5) | 12 (12.0) | 0.123 |
| Household accidents including burns | 13 (7.7) | 20 (20.0) | 0.003 |
| Cellulitis, ulcer, wound | 22 (13.1) | 4 (4.0) | 0.014 |
| Other (dog bite, crush injuries, lacerations) | 31 (18.4) | 3 (3.0) | - |

Values are presented as number (%).
[a)]23 January–22 March, 2020; [b)]23 March–22 May, 2020; [c)]Significant at P<0.05.

**Table 3.** Consultations and procedures performed in the ER and OR

| Variable | Prelockdown[a)] (n=168) | Postlockdown[b)] (n=100) | P-value[c)] |
|---|---|---|---|
| No. of cases physically attended in ER | 164 (97.6) | 62 (62.0) | <0.01 |
| Minor procedures in ER | 90 (53.5) | 72 (72.0) | <0.01 |
| Procedures in OR | 67 (39.8) | 18 (18.0) | <0.01 |
| No procedure required | 11 (6.5) | 10 (10.0) | - |

Values are presented as number (%).
ER, emergency room; OR, operating room.
[a)]23 January–22 March, 2020; [b)]23 March–22 May, 2020; [c)]Significant at P<0.05.

significant increase in the number of cases done in the procedure room compared to prelockdown, from 53.5% to 72.0% (P = 0.002). All procedures in the emergency department were performed under local anesthesia. The number of patients requiring major surgical interventions in the operating room decreased significantly, by 73.1%, during lockdown (67 vs. 18, P = 0.001) and these were the patients who required surgery under general anesthesia (Table 3).

## DISCUSSION

The COVID-19 pandemic had a profound impact on individual lifestyles, which was amplified by the effects of social distancing and intermittent lockdown. The complete restriction of transport was expected to result in a decrease in road traffic and motor vehicle collision accidents. The dip in the absolute number of road crash fatalities during lockdown is mainly attributed to the suspension of public transport and general mobility. This decline in traffic accidents during COVID-19 lockdowns has been noted across the world in academic articles from Spain [5], Brazil [6], India [7], and the United States [3,8], as well as in the media.

In India, the lockdown resulted in a significant reduction in the number of road traffic accidents. Statistics suggest that roughly about 10,000 lives were saved by the lockdown in India in 1 month due to road traffic accidents, relative to a loss of 200 lives due to COVID-19. According to the data provided to the Supreme Court Committee on Road Safety, there was a 68% decrease in deaths due to road traffic accidents during the lockdown between March 24 and May 31 and a 72% decrease in road accident injuries [4]. Bihar (where our institution is located) is the state that observed the fourth-highest declines—with a 58.5% decline in road deaths and 56.6% decline in injuries sustained due to road traffic accidents—during lockdown, after Maharashtra, Rajasthan, and Gujarat [4]. The percentage decrease in Bihar was considerably higher than in metropolitan cities (e.g., central Mumbai), where the number of deaths fell by about 21% in March compared with the same month in 2019 [9]. In our study, the absolute number of emergency cases decreased from 168 in the prelockdown period to 100 in the postlockdown period. Although road traffic accidents remained the most common cause in both periods (45.8% vs. 39.0%), the numbers decreased during the lockdown (77 vs. 39). Studies at various centers from the United States have shown similar patterns, with stay-at-home orders resulting in a decreased volume of plastic surgery consults in the emergency department [10,11].

There was a significant increase in the proportion of assault injuries seen in the postlockdown period, particularly gunshot and stab injuries (4.1% vs. 13%, P = 0.007). The reason for the increase in gunshot injuries was festive gunfire at marriages taking place in the month of May during the lockdowns 3 and 4 when flight services resumed. The proportion of injuries sustained at home, including burns, increased significantly from 7.7.% to 20.0% in the lockdown phase (P = 0.003). This shows a correlation between staying at home and a propensity for household injuries. The presentation of nontraumatic cases including cellulitis, ulcers, wounds, and other causes (e.g., dog bites, crush injuries, and lacerations) decreased considerably during lockdown (31.5% vs. 7.0%).

Healthcare workers, including doctors and staff, faced a major challenge while managing the emergency patients during the prevailing COVID-19 pandemic. In semiurgent cases, the surgical intervention was done only after the patient's COVID-19 status was confirmed by RT-PCR, but this was not possible in cases requiring immediate surgical management or for patients who underwent minor procedures in the emergency room. The second group included maxillofacial injuries requiring intermaxillary fixation debridement, suturing of lacerated wounds, and dressings. As the COVID-19 status of those patients was unknown, they were considered positive and the utmost precautions were taken by all healthcare workers (including the usage of PPE and face shields), especially when managing complex craniofacial trauma cases where a comprehensive examination relies on close proximity to the patient's nose and mouth [12]. The overall number of personnel involved in the management of any case was kept minimal, both with the goal of avoiding exposure and keeping in mind the shortage of PPE.

Based on the policies followed by our institution and our plastic surgery team, fewer cases were physically seen in the emergency room (97.6% vs. 62.0%). In cases where other associated injuries were present, an attempt was made to coordinate the consultation with other specialty teams, such as neurosurgery, orthopedics, and general surgery. The collected data showed an increase in the number of minor procedures done at the first consultation during the lockdown period (53.5% vs. 72.0%, P = 0.002). Immediately necessary surgical procedures were done without delay whenever indicated. Once admitted, the patients had somewhat longer stays in the hospital (mean ± standard deviation, 8.4 ± 2.3 days vs. 14.6 ± 3.4 days). The reasons for this included the goal of obtaining RT-PCR at least 12 hours before the patient was taken up for surgical procedure, requests from patient family members to postpone discharge due to the unavail-


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ability of transport during lockdown, and an inability to come for dressing changes usually done on an outpatient basis before lockdown.

In conclusion, the COVID-19 pandemic and lockdown orders in India greatly influenced trends in traumatic emergencies as observed by the plastic surgery team at our tertiary care center. Amidst all the chaos and limitations of the COVID-19 pandemic, safe and timely care provided by the team for our patients remained our top priority. The overall decrease in the plastic surgery emergency case volume was 40.4%, and the number of daily consultations decreased (2.8 vs. 1.6) during lockdown. Road traffic accidents remained the most common mechanism of injury in both periods (45.8% vs. 39.0%) but decreased in number during the lockdown (77 vs. 39). The proportion of household accidents, including burns, increased significantly from 7.7.% to 20.0% in the lockdown phase. The proportion of procedures done in the emergency department increased from 53.5% to 72.0% during lockdown in order to restrict the movement of patients and avoid the exposure of additional healthcare workers. Apart from imparting optimal patient care, the safety of doctors and staff members was also a major concern at our hospital. The lesson learnt from lockdown during this pandemic is that just as the specialty of plastic surgery involves the molding of any structure, our team also molded itself and adapted to the sudden setbacks as expressed by the continuation of safe and timely care provided by our team with thorough communication, vigilance, and guidance on our part.

## NOTES

### Ethical statements

The study was approved by the Institutional Review Board of All India Institute of Medical Sciences (No. AIIMS/Pat/IEC/2020/564) and performed in accordance with the principles of the Declaration of Helsinki. Since it was a retrospective study, telephonic informed consent was obtained from the patients.

### Conflicts of interest

The authors have no conflicts of interest to declare.

### Funding

None.

### Author contributions

Conceptualization: VS; Data curation: AdK, AmK; Formal analysis: VS, AH, SS; Visualization: SK, AnK; Writing–original draft: VS; Writing–review & editing: AH, SS.
All authors read and approved the final manuscript.

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Case Report

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# A case report of "minor" trauma leading to a major disability: whiplash-associated dysphagia, dysphonia, and dysgeusia

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"Whiplash"-type injuries are commonly encountered and often cause neck pain, neck stiffness, and headaches. However, these injuries can have rare and poorly recognized complications, such as the development of a prevertebral hematoma leading to acute respiratory failure in the emergency department, followed by severe, life-threatening dysphagia and recurrent aspirations. In the patient described herein, a whiplash injury was accompanied by vocal cord paralysis and dysphonia (vagus nerve), dysgeusia (glossopharyngeal nerve, vagus nerve), and upper esophageal spasm (cricopharyngeal muscle, vagus nerve). It is unlikely that this was a complication of cervical fusion surgery. Instead, a combined stretch-induced lower cranial nerve injury, possibly on the exit of these nerves through the jugular foramen, seems to be a likely, but underappreciated mechanism occurring in rare instances of whiplash injuries.

**Keywords:** Whiplash injuries; Oropharyngeal dysphagia; Cranial nerves; Dysphonia; Case report

## INTRODUCTION

Blunt impact in motor vehicle collisions is not infrequently associated with sudden acceleration and deceleration, causing rapid extension of the head and neck followed by flexion [1]. These "whiplash" injuries often cause neck pain, neck stiffness, and headaches. However, prevertebral hematoma development and marked dysphagia are rare and poorly recognized complications [2].

## CASE REPORT

An 80-year-old engineer driving home from work was hit by a bus from behind, and his vehicle collided with a fence. He had been on rivaroxaban and bisoprolol for paroxysmal atrial fibrillation. In the emergency department, he was alert and stable, and he complained of right neck pain where a hematoma was noted.

Head and chest computed tomography (CT) were normal. Neck CT revealed a cervical prevertebral hematoma and fractured posterior tubercle of C4 (Fig. 1). The spinal cord showed no changes, as was also the case on subsequent magnetic resonance imaging, and the neurological examination was normal. Sudden respiratory failure mandated intubation, which was difficult to perform. He was given prothrombin complex concentrate to reverse rivaroxaban and underwent surgery on the next day with cervical fusion (C2–C7, posterior approach) and later, dexamethasone. After 2 weeks, it was deemed necessary to perform discectomy and fusion (C4–C5, anterior approach). After 3

**Fig. 1.** Sagittal reconstruction of noncontrast neck computed tomography done soon after the patient's emergency department presentation, showing a large prevertebral hematoma (arrowheads) extending from the base of the skull to the upper mediastinum and fracture of the C4 spinous process. In addition, florid spondylotic degenerative changes, including coarse anterior and posterior osteophytes, synostosis of the C3 and C4 vertebral bodies, and discal changes can be seen.

weeks of intensive care due to recurrent pneumonia, the patient was extubated and started feeding. However, dysphagia with both solid and liquid foods appeared and persisted, associated with coughing, regurgitation, dysphonia, and dysgeusia causing dehydration, progressive distress, depression, and malnutrition (58 kg at 1 year vs. 71 kg prior; albumin, 1.8 g/dL vs. 3.8 g/dL) associated with extreme lassitude and marked functional decline and dependence. Dysphagia was suspected 3 weeks after the nasogastric tube was removed, but the full investigations took several months to obtain. The swallowing examinations were performed at an outpatient clinic specializing in swallowing disorders and were done 5 to 6 months after discharge. The investigations confirmed oropharyngeal dysphagia with normal tongue and lip function, a normal gag reflex, no dysarthria, or focal pyramidal signs, but hoarseness and right vocal cord paralysis on laryngoscopy. Fiberoptic endoscopic examination of swallowing (FEES) demonstrated food pooling in the valleculae, regurgitation, and liquid penetration triggering coughing. A videofluoroscopic evaluation with liquid barium and wet bread confirmed the FEES findings and also revealed failed relaxation of the upper esophageal sphincter with a normal esophageal phase. Eventually, after various oral intake manipulations failed, a nasogastric tube was inserted. When weight loss and hypalbuminemia persisted, parenteral nutrition through a peripherally inserted central catheter was instituted. The patient died of pneumonia 16 months after the accident.

## DISCUSSION

Dysphagia, a subjective sensation of difficulty of swallowing with or without pain (odynophagia), signifies an abnormality in the passage of solid food and/or liquids from the oral cavity to the stomach. Practically, oropharyngeal versus esophageal dysphagia can be distinguished, and each subset has multiple etiologies. When evaluating dysphagia, good history-taking can often direct the clinician to the underlying cause. For example, oropharyngeal dysphagia is frequently characterized by difficulty in initiating swallowing, feeling of food sticking in the throat and associated "early" coughing and choking, often with pharyngeal complaints (nasal regurgitation, sialorrhea, changed voice) and recurrent aspiration pneumonia [3,4].

Our patient's isolated neck trauma seemed minor at first, but there is no doubt that his anticoagulant treatment contributed to the growth of the hematoma, airway compression, and acute respiratory failure (Fig. 1) [2]. Other notable features included persistent oropharyngeal dysphagia (as described above) causing progressive malnutrition, weight loss, hypalbuminemia, and aspiration pneumonia, ultimately leading to his demise. This occurred with only a minor fracture and no demonstrable neurological deficit or cord involvement on neuroimaging.

Unlike cervical osteoarticular disease, which is an acknowledged although uncommon cause of oropharyngeal dysphagia, whiplash-associated cranial nerve injury and anatomical changes of the oropharynx with dysphagia have been rarely reported [5,6]. In view of the patient's associated vocal cord paralysis and dysphonia (vagus nerve), dysgeusia (glossopharyngeal nerve, vagus nerve), and upper esophageal sphincter spasm (cricopharyngeal muscle innervated by the vagus), a combined stretch-induced lower cranial nerve injury, possibly on the exit of these nerves through the jugular foramen, seems likely. Patients may develop dysphagia after cervical surgery, but unlike our patient, their dysphagia is isolated and usually improves over 6 months; severe dysphagia is rare (e.g., 6 of 186 patients, 3.2%) [7]. Thus, physicians in the emergency department and varied disciplines need to be aware of the unusual but highly disabling association of misleadingly "simple" whiplash injury with acute respiratory failure and subsequent significant impairment of swallowing, phonation, and taste.


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## NOTES

### Ethical statements

Informed consent for publication of the research details and clinical images was obtained from the patient's next of kin.

### Conflicts of interest

The authors have no conflicts of interest to declare.

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None.

### Author contributions

Conceptualization: AS; Data curation: all authors; Formal analysis: AS; Writing–original draft: AS; Writing–review & editing: all authors. All authors read and approved the final manuscript.

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Case Report

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# Thoracoabdominal injury with evisceration from a chainsaw assault: a case report

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The usual cause of penetrating thoracoabdominal injuries with evisceration are stab wounds with knives and other sharp weapons used during fights and conflicts. Evisceration of the abdominal viscera as a result of trauma, with its attendant morbidity and mortality, requires early intervention. Gunshot wounds can also cause penetrating thoracoabdominal injuries. We report the case of a 52-year-old male patient, a worker at a timber-processing factory, who was assaulted with a chainsaw by his colleague following a disagreement. He was seen at the accident and emergency department of Olabisi Onabanjo University Teaching Hospital, Sagamu, Nigeria with a thoracoabdominal injury about 1.5 hours after the attack. He had a left thoracoabdominal laceration with abdominal evisceration and an open left pneumothorax. He was managed operatively, made a full recovery, and was discharged 16 days after admission. He was readmitted 4 months after the initial surgery with acute intestinal obstruction secondary to adhesions. He underwent exploratory laparotomy and adhesiolysis. He made an uneventful recovery and was discharged on the 9th postoperative day for subsequent follow-up.

**Keywords:** Chainsaw injury; Evisceration; Penetrating injury; Thoracoabdominal injury; Case report

## INTRODUCTION

Thoracoabdominal injuries may be blunt or penetrating. Penetrating thoracoabdominal injuries (PTAIs) are associated with a high mortality rate (up to 31%) [1]. The concern is that diaphragmatic and pleural breach may lead to contamination, infection, and collection, resulting in morbidity and mortality. PTAIs affect two anatomical cavities, and the difficulty of surgical management may therefore be considerable, depending on the organs injured. Diaphragmatic injuries associated with penetrating PTAIs can cause severe morbidity and mortality if undetected. Laparoscopy is therefore a useful tool for detecting diaphragmatic injuries in penetrating thoracoabdominal stab wounds [2]. Patients with PTAIs have an overall incidence of diaphragmatic injuries of about 42% [3].

Patients with major thoracic vessel injuries or aortic injuries have a lower chance of survival and often die before arrival at the hospital. The trajectory of the offending weapon or missile determines the organs involved, especially if it traverses the diaphragm. Stab wounds are a common cause of abdominal eviscer-

ation [4,5] and the knife is the commonest offending weapon apart from broken bottles and glass [6].

A chainsaw is a hand-held powered equipment used by loggers in the timber industry for felling trees and cutting timber. It is a commonly used tool that has a risk of causing severe injuries. It cuts with a set of teeth attached to a rotating chain driven along a guide bar. Chainsaws were found to be the cause of about 15.5% of severe injuries in a work-related setting [7]. Injuries from chainsaws are usually accidental. The feet are the most frequently seriously injured part of the body, while the torso, shoulder, and neck are the least injured [8]. A literature search did not reveal any cases of combined thoracoabdominal injuries with evisceration from either accidental chainsaw injuries or chainsaw assault. We therefore report the case of a patient who was assaulted on the torso with a chainsaw at a timber-processing factory, resulting in a thoracoabdominal injury with abdominal evisceration and open pneumothorax.

## CASE REPORT

The patient was a 52-year-old worker at a timber logging factory who was assaulted by a coworker on the torso with a chainsaw following a conflict. He was seen at the emergency department of Olabisi Onabanjo University Teaching Hospital, Sagamu, Nigeria about 1.5 hours after the injury (Fig. 1). He had lost an estimated 500 mL of blood. His last meal was about 7 hours before the injury. He had no known comorbidities, such as diabetes mellitus or hypertension.

The patient was found to be a middle-aged man, conscious, and with a pale complexion, with blood-stained clothing wrapped over the chest and over the exposed abdominal viscera (Fig. 1). His hemodynamic status was stable, with a heart rate of 96 beats/min, and blood pressure of 110/70 mmHg. He was tachypneic, with a respiratory rate of 36 breaths/min. The packed cell volume was 33%, serum electrolytes and urea were normal, and one unit of whole blood was cross-matched.

There was a ragged spiral laceration extending from the lateral aspect of the lower left hemithorax to about 4 cm to the left of the umbilicus. Evisceration of the stomach, small bowel, and transverse colon was observed (Fig. 2). A laceration of the stomach discharged gastric contents, which stained the eviscerated organs. There was no active bleeding except for mild bleeding from the edges of the thoracoabdominal wound, which penetrated the left thoracic cavity. There was tenderness and crepitation over the left lower ribs. Reduced movement of the left hemithorax with respiration was observed, and no air entry was noted in the middle and lower chest zones. There were no other associated external injuries.

**Fig. 1.** Patient brought in showing a 30-cm thoracoabdominal laceration. The clothing used to wrap the bowel was removed.

He was commenced on intravenous fluids, nasogastric intubation, and urethral catheterization. The exposed viscera were irrigated with normal saline and packed with gauze. He was commenced on intravenous ceftriaxone 1 g at 12-hour intervals and intravenous metronidazole (500 mg) at 8-hour intervals. His initial oxygen saturation level ($SpO_2$) was 92% and he was commenced on oxygen using a nasal cannula with prongs. He was moved to the operating room for exploration and repair after a thorough assessment.

### Operative findings and treatment

Exploration was carried out through the penetrating thoracoabdominal laceration caused by the chainsaw. There was no need to extend the thoracoabdominal wound because it was adequate for exploration. The wound measured about 30 cm in length from the lower left chest wall to the left of the midline of about 4 cm from the umbilicus. The eviscerated viscera included the stom-

**Fig. 2.** Full exposure after cleaning up with no other associated external injury.

**Fig. 3.** Immediate postoperative view with the abdominal drain *in situ*.

ach, small bowel, and transverse colon. There was a 4-cm laceration along the greater curvature of the stomach discharging gastric contents. Exploration of the abdomen revealed a small capsular laceration of the spleen on the anterior margin held together by blood clots. There was a laceration of the left hemidiaphragm about 8 cm in length, through which the lower lobe of the lung herniated into the peritoneal cavity. The seventh to 12th ribs were fractured with mild hemothorax.

The eviscerated organs were irrigated copiously with normal saline. The edge of the stomach laceration was freshened before its repair in two layers. The capsular laceration on the spleen was repaired. The left hemothorax was aspirated and the diaphragm repaired. Debridement of the thoracoabdominal wound was carried out before closure in layers, leaving an intraperitoneal drain *in situ* (Fig. 3). Left closed thoracostomy tube drainage was done and the patient was moved to the intensive care unit for postoperative monitoring after extubation. The estimated blood loss during surgery was about 200 mL and the patient received an intraoperative transfusion with one unit of whole blood. Oxygen supplement was discontinued about 3 hours postoperatively when patient was fully awake and his $SpO_2$ at 4 hours postoperatively was 99% on room air. On postoperative day 2, he was commenced on chest physiotherapy and early mobilization, and his postoperative packed cell volume was 32%. The nasogastric tube was removed on postoperative day 3 when bowel sounds became active, and he was commenced on oral intake. The wound was reviewed on postoperative day 5 (Fig. 4). His chest tube was removed on postoperative day 9 and he was discharged on postoperative day 16 in satisfactory condition.

The patient presented again 4 months after discharge with features of acute intestinal obstruction. The findings were in keeping with intestinal obstruction secondary to adhesions. He underwent exploratory laparotomy and adhesiolysis and was discharged on postoperative day 9 in satisfactory condition.

## DISCUSSION

This patient was assaulted with a chainsaw, which is not a con-


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**Fig. 4.** Five days postoperatively, the patient sitting up with the wound exposed and chest tube *in situ*.

ventional weapon. Usually, attacks and fights are carried out using knives or broken bottles [6]. A chainsaw is a powered handheld tool that is capable of accidentally causing severe and devastating traumatic injuries. Severe accidental injuries such as amputations, fractures, and maxillofacial injuries have been reported [9,10]. Deaths from chainsaw accidents have also been reported, although they are rare [11], and suicide using a chainsaw has also been reported [12]. There are published works on accidental chainsaw injuries related to occupational use [7,8,13], but we did not find any previous reports of chainsaw injuries due to assault.

The risk factors for morbidity and mortality include the length of time between the injury and surgery, and presence of shock at the time of admission [14]. This patient was seen in the accident and emergency department about 1.5 hours after the injury, and underwent surgery about 2 hours later, making the total interval until surgical intervention approximately 3.5 hours. A surgical intervention time of less than 1 hour in patients with abdominal trauma that required surgery was associated with better outcomes [6]. This surgical intervention time of less than 1 hour can be achieved in places where there are efficient helicopter and ambulance services. This patient was hemodynamically stable at the time of admission in the accident and emergency department, and this was because he did not sustain any major vascular injury. This was an important factor that contributed to his recovery. The exposed viscera were covered with gauze soaked in saline to minimize fluid loss and protect the viscera. The successful outcome and recovery of this patient were also due to prompt resuscitation and early operative intervention.

The extent of the associated chest injury was identified during surgery; the patient underwent diaphragm repair and had left closed thoracostomy tube drainage. The possibility of diaphragmatic injury must always be suspected with PTAIs. This patient received broad-spectrum antibiotics because of the potential contamination of the pleural and peritoneal cavities at the time of injury. The chest tube was left until there was no sign of infection or collection. Intestinal obstruction secondary to adhesions, which occurred 4 months after the initial surgery in this case, is a known complication of exploratory laparotomy [15]. Since a chainsaw can be used as a lethal weapon, workers who use this equipment may require a psychological assessment and background check before employment to prevent this type of incident.

## NOTES

### Ethical statements

This study was approved by the Health Research Ethics Committee of Olabisi Onabanjo University Teaching Hospital (No. OOUTH/HREC/394/2021), in accordance with the principles of the Declaration of Helsinki. Informed consent for publication of the research details and clinical images was obtained from the patient.

### Conflicts of interest

The authors have no conflicts of interest to declare.

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### Author contributions

Conceptualization: BAS; Visualization: BAS, EAS; Writing–original draft: all authors; Writing–review & editing: all authors.
All authors read and approved the final manuscript.

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Case Report

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# Case reports of iatrogenic vascular injury in the trauma field: what is the same and what is different?

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Iatrogenic vascular injury (IVI) can occur with any technique or type of surgery performed around a blood vessel. Patients with severe trauma are at risk of IVI. In this study, we describe our experiences of IVI in the trauma field. We reviewed five patients who were diagnosed with an IVI and received either surgical or endovascular treatment. Of the five patients, one had an arterial injury, three had venous injuries, and one had an arteriovenous fistula, a form of combined arterial and venous injuries. Of the five patients, four had undergone orthopedic surgery. The IVIs of three patients were immediately identified in the operating room and simultaneous vascular repair was performed. The remaining one patient underwent additional surgery for occlusion related to entrapment of the superficial femoral artery by a surgical wire used during orthopedic surgery. Complications presumably related to the IVI were identified in two patients. IVI in trauma patients can be successfully managed, but significant morbidity can occur. If an IVI is suspected, immediate evaluation and management are required.

**Keywords:** Vascular injury; Iatrogenic injury; Complications; Case report

## INTRODUCTION

Iatrogenic vascular injury (IVI) can occur in various medical and surgical settings. As endovascular procedures have been widely used to diagnose and treat patients, the frequency of IVI is reported to have increased [1,2]. Cases of IVI occur during surgery and other situations that require vascular access [3]. However, IVI in the trauma field has not been characterized and investigated. An early multidisciplinary approach and emergency surgery are required for patients with severe trauma to assess the extent of organ damage and the complexity of the injury. Multiple vascular access sites are often required to respond to early shock and/or for longterm intensive care unit (ICU) treatment and monitoring [4]. IVI can cause secondary damage in trauma patients by creating an additional cycle of bleeding [3]. This study describes our experiences with IVIs during surgical or endovascular treatments at a single regional trauma center.

## CASE REPORTS

Clinical characteristics of five patients treated for IVI, and diagnostic and treatment strategies and clinical outcomes are summarized in Tables 1, 2. Informed consent for publication of the research details and clinical images was obtained from all individual participants included in this study.

### Case 1

A 71-year-old male patient who was undergoing regular hemodialysis through the right native forearm arteriovenous fistula (AVF) for underlying end-stage renal disease presented to the emergency room (ER) complaining of pain in the right shoulder due to trauma. The patient was diagnosed with a surgical neck fracture of the right humerus on examination, and open reduction and internal fixation (ORIF) was performed on the third day of admission. During the operation, bleeding occurred due to damage to the distal cephalic vein. In order to maintain the native AVF, the trauma vascular surgeon was contacted, and primary lateral repair was performed simultaneously. After the operation, hemodialysis was attempted through the AVF according to the regular dialysis schedule and hemodialysis proceeded without any problems.

### Case 2

A 37-year-old male patient without underlying disease presented to the ER complaining of damage caused when his left lower extremity (LE) was caught between a forklift and a railing. The patient was diagnosed with a left tibiofibular open fracture with a popliteal artery injury, and emergency surgery was performed. According to the surgical findings, popliteal artery transection was confirmed, and segmental interposition using the reversed greater saphenous vein was performed. After vascular surgery, the orthopedic surgery team took over the operation and performed ORIF. After surgery, there was sudden bleeding at the site of vascular surgery. As a result of revision, the popliteal vein injury, which was intact, was confirmed. The popliteal vein was transected, and proximal and distal ligations were performed in a situation where approximation was not possible. The patient had substantial muscle mass and the ischemia time was approximately 4 hours. The calf was firm to palpation at the time of revision and prophylactic fasciotomy was performed to prevent progression to compartment syndrome. After 12 days, external fixation conversion was performed, and 16 weeks of wound care were required in collaboration with a plastic surgeon.

### Case 3

A 30-year-old male patient, complaining of abdominal pain following a traffic accident (TA), presented to the ER. The patient was admitted to the ICU due to the possibility of damage to the abdominal wall and internal organs and was clinically followed. A central line insertion was attempted through the right internal

**Table 1.** Clinical characteristics of five patients treated for IVI

| Patient | Age (yr) | Sex | Diagnosis related with IVI | Site | Vessel related with IVI | Pathology | ISS |
|---|---|---|---|---|---|---|---|
| 1 | 71 | Male | Humerus fracture | Right | Cephalic vein (AVF for dialysis) | Bleeding | 5 |
| 2 | 37 | Male | Tibio-fibula fracture popliteal artery transection | Left | Popliteal vein | Bleeding | 13 |
| 3 | 30 | Male | S-colon perforation | Right | Subclavian artery, internal jugular vein | AVF | 5 |
| 4 | 75 | Female | Femur fracture | Right | Superficial femoral artery | Occlusion (entrapment) | 25 |
| 5 | 83 | Female | Pelvic fracture | Left | External iliac vein | Bleeding | 22 |

IVI, iatrogenic vascular injury; ISS, Injury Severity Score; AVF, arteriovenous fistula.

**Table 2.** Diagnostic and treatment strategies and clinical outcomes in five patients with IVI

| Patient | Diagnostic modality (interval, day) | Treatment | Complication | ICU stay (day) | Hospital stay (day) |
|---|---|---|---|---|---|
| 1 | Operative finding (0) | Lateral repair | None | 0 | 3 |
| 2 | Operative finding (0) | Ligation | Calf swelling | 7 | 120 |
| 3 | CT angiography (6) | Angio-embolization | None | 0 | 29 |
| 4 | CT angiography (14) | Graft interposition | Foot drop | 33 | 133 |
| 5 | Operative finding (0) | Segmental R&A | None | 17 | 33 |

IVI, iatrogenic vascular injury; ICU, intensive care unit; CT, computed tomography; R&A, resection and anastomosis.


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jugular vein (IJV) during resuscitation in the ER. An arterial puncture occurred during the attempt to insert a central venous catheter, and the procedure was stopped. No additional complications were observed at the site. On the second day of hospitalization, the patient complained of abrupt abdominal pain, suggesting peritoneal irritation, and emergency exploratory laparotomy was performed. According to the surgical findings, ischemic sigmoid colon perforation caused by damage to the sigmoid mesocolon was diagnosed, and a Hartmann procedure was performed. On the day after surgery, thrill and bruit were observed in the patient's right neck, and arterial flow in the jugular vein was confirmed by bedside Doppler ultrasonography. An additional examination was planned for a suspected iatrogenic AVF. A subclavian artery to IJV AVF was confirmed by computed tomography angiography of the neck (Fig. 1A). Conventional angiography was performed to control the fistula tract (Fig. 1B). After selecting the tract, multiple coil embolization was performed. The final angiography after the procedure confirmed that there was no arterial flow into the IJV (Fig. 1C). There were no additional vascular complications on subsequent follow-up.

## Case 4

A 75-year-old female patient who was diagnosed with a right femur fracture, multiple pelvic fractures, bladder injury, and a fifth lumbar vertebral body fracture due to a pedestrian TA was transferred from a local hospital to the trauma center through the ER for further evaluation and treatment. The patient was admitted to the ICU, and closed reduction and internal fixation for the femur fracture and surgery for the pelvic fractures were performed on the seventh and 11th days after admission, respectively. Postoperatively, there were findings of suspected ischemic injury in the right LE. The initial findings were suspicious for underlying vascular disease, but additional examinations were planned according to the progressive findings. On computed tomography angiography of the LE, segmental arterial occlusion was found at the site of the femur fracture, and findings adjacent to the orthopedic surgical site were observed (Fig. 2A). Therefore, additional surgery was performed, which confirmed that the superficial femoral artery was entrapped by two of the surgical wires used during closed reduction and internal fixation (Fig. 2B). The surgical wires were removed and segmental interposition using a prosthetic graft for the injured superficial femoral artery was performed. There were no additional vascular complications, although the patient did show foot drop during the recovery process, a possible sequela of ischemic peripheral nerve damage.

## Case 5

An 83-year-old female patient presented to the ER complaining of multiple injuries caused by a pedestrian TA. The patient was admitted to the ICU after being diagnosed with a seventh cervical vertebral body fracture, multiple rib fractures, sternum fracture, multiple pelvic fractures, left tibiofibular fracture, and left shoulder fracture. On the 4th day of admission, surgery was performed for her sternum fracture, multiple pelvic bone fractures, and left tibiofibular fracture. Sudden bleeding was observed at the time of placement of a drainage tube for surgical bed drainage during surgery for the pelvic fracture. A left external iliac

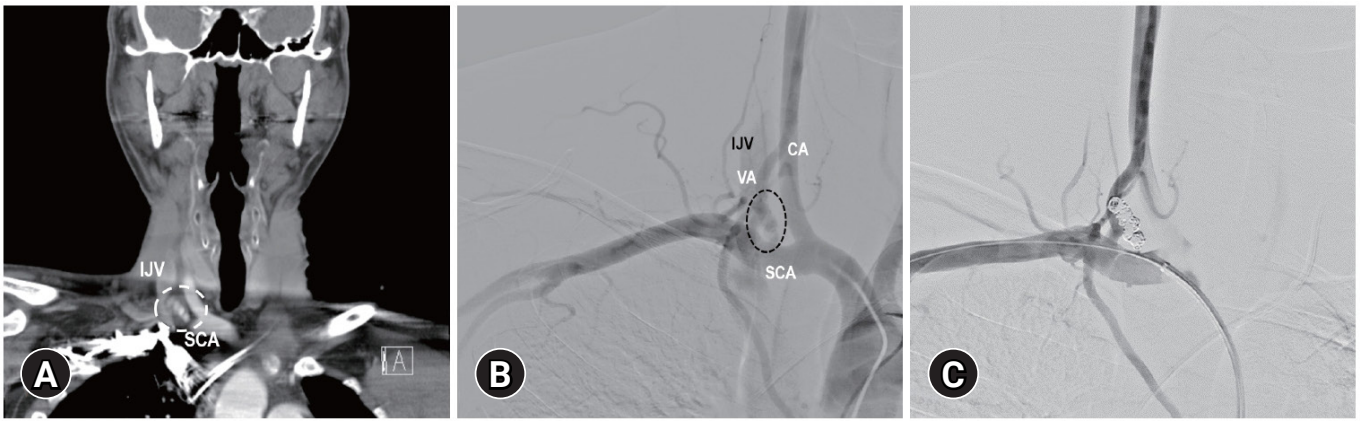


**Fig. 1.** Arteriovenous fistula between internal jugular vein (IJV) and subclavian artery (SCA) in case 3. (A) Findings of computed tomography angiography. Fistula tract (dotted circle) observed between IJV and SCA. (B) Findings of conventional angiography. Fistula tract (dotted circle) and IJV shown with contrast on angiography. (C) Arteriography after embolization with multiple coils confirmed that there was no contrast of the IJV. CA, carotid artery; VA, vertebral artery.

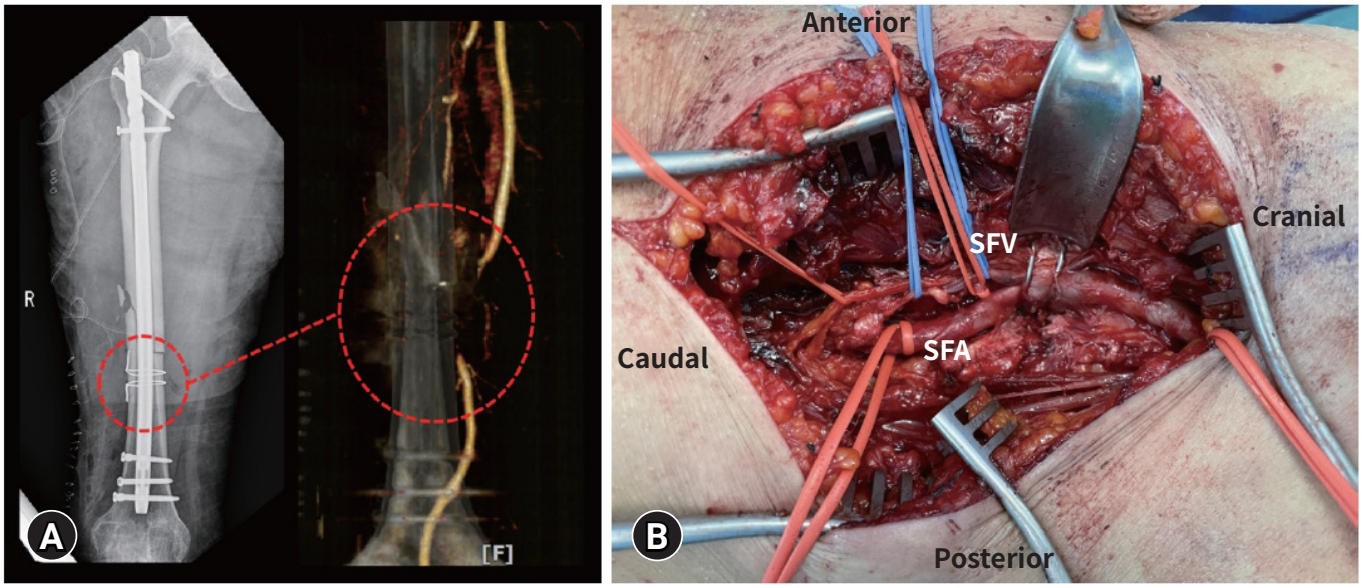


**Fig. 2.** Superficial femoral artery (SFA) entrapment by two surgical wires used during surgery for femur fracture in case 4. (A) Findings of X-ray and computed tomography angiography. The occluded segment of SFA on computed tomography angiography corresponds to the area of surgical wires applied on X-ray (dotted circle). (B) Operative findings. SFV, superficial femoral vein.

vein injury was suspected, and the trauma vascular surgeon was contacted. On exploration of the bleeding site, anteroposterior penetration of the left external iliac vein was confirmed. Segmental resection and endto-end anastomosis were performed for the injured vein. The patient recovered without additional vascular complications.

## DISCUSSION

IVI is a generic term for vascular damage that occurs during medical diagnostic examination and treatment, and may appear as arterial, venous, or combined arteriovenous damage [5]. The injury can present as bleeding, hematoma, intimal damage, occlusion, or an AVF, and treatment is based on the anatomy, physiological characteristics, and target organ perfusion of the damaged blood vessel [6]. Of the five cases in our institution, there was one case of arterial injury, three cases of venous injury, and one case of AVF in which both artery and vein were damaged. Bleeding occurred in all venous injuries, and the one arterial case was occlusion by entrapment. There were three cases of pseudoaneurysm of the deep femoral artery, suspected of being IVI, but the possibility of damage at the time of trauma due to fracture could not be completely ruled out, so they were excluded.

As endovascular treatments have become more common and the target applications have become more diversified, the incidence of IVI related to endovascular treatment has increased [1,2,6]. Among trauma patients at our institution, three cases of IVI occurred during an endovascular procedure and all were related to puncture site bleeding and hematoma. Two cases improved with conservative treatment, and one case was treated with a simultaneous endovascular procedure.

As the role of endovascular procedures expands in the trauma field, reports of IVI should be studied and fully considered [7]. However, IVI in the trauma field must also be considered in terms of trauma dealing with multi-organ complex injuries and critically ill patients, multidisciplinary emergency surgery, and specialties related to long-term intensive care [8–10].

Traditional vascular surgical procedures such as primary repair, ligation, and thrombectomy with angioplasty, as well as more recent interventions utilizing endovascular procedures, are widely performed today [11,12]. Early diagnosis and treatment, as well as early intervention by a vascular specialist, are essential [4].

As shown in the cases of this study, early detection of damage and simultaneous intervention can result in a stable course, without additional surgery or procedures. Conversely, if the radiological diagnosis of IVI is made postoperatively, after symptoms develop, delayed diagnosis and treatment may result in additional procedures or surgery. In this study, in cases 3 and 4 with delayed diagnosis of IVI, the occurrence of complications related to delayed diagnosis was not observed. Delayed diagnosis of IVI


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which may result in prolonged bleeding or ischemia increases the risk.

In terms of early diagnosis and treatment approaches, the treatment strategy for IVI as well as traumatic vascular injury is solid. When considering the characteristics of patients with severe trauma during early multidisciplinary emergency surgery and procedures, it should be possible to distinguish an IVI from a natural traumatic vascular injury.

IVI in trauma patients can be successfully managed, but significant morbidity can occur. If IVI is suspected, immediate evaluation and appropriate management are required.

## NOTES

### Ethical statement

Informed consent for publication of the research details and clinical images was obtained from all individual participants included in this study.

### Conflicts of interest

Min Ae Keum serves on the Editorial Board of *Journal of Trauma and Injury*, but was not involved in the peer reviewer selection, evaluation, or decision process of this article. The authors have no other conflicts of interest to declare.

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### Author contributions

Conceptualization: all authors; Data curation: YK, MN; Methodology: YK, KC, MN; Project administration: SC, MN; Visualization: SC, MAK, MN; Writing–original draft: YK, KC, MN; Writing–review & editing: YK, SK, KHK, JTK.

All authors read and approved the final manuscript.

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Case Report

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# Successful endovascular embolization for traumatic subcutaneous abdominal wall hematoma via the superficial inferior epigastric artery: a case report

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Abdominal wall hematoma (AWH) after blunt trauma is common, and most cases can be treated conservatively. More invasive treatment is required in patients with traumatic AWH if active bleeding is identified or there is no response to medical treatment. Herein, we report a case of endovascular embolization for traumatic subcutaneous AWH. Almost endovascular treatment for AWH is done through the deep inferior epigastric artery. However, in this case, the superficial inferior epigastric artery was the bleeding focus and embolization target. After understanding the vascular system of the abdominal wall, an endovascular approach and embolization is a safe and effective treatment option for AWH.

**Keywords:** Abdominal wall; Hematoma; Endovascular procedure; Epigastric artery; Case report

## INTRODUCTION

Abdominal wall injuries are found in approximately 9% of patients after blunt trauma. Most patients present with lower-grade injuries, ranging from subcutaneous contusion to abdominal wall hematoma (AWH) [1]. Some cases of AWH are accompanied with active bleeding, which may result in serious complications such as anemia, hypovolemic shock, and muscle necrosis from compartment syndrome [2]. Most patients with abdominal wall contusion or hematoma can be managed conservatively with blood transfusion. If conservative management fails, patients might require more invasive treatment [1]. Although no definite treatment guideline for AWH has been established, in recent years the endovascular approach for embolization has been more often used than surgical treatment [3]. We report a case of embolization of the superficial inferior epigastric artery (SIEA) for a trauma patient with active subcutaneous bleeding.

## CASE REPORT

A 25-year-old male patient was transported to the emergency department following a motor vehicle accident. On arrival, his vitals were stable (blood pressure, 140/100 mmHg; pulse rate, 85 beats/minute; and respiratory rate, 16 breaths/minute). He was conscious and complained of lower abdominal pain. On abdominal computed tomography, multifocal abdominal wall contusion with focal active bleeding was noted. The active bleeding focus was the subcutaneous layer and anterior aspect of the right rectus abdominis muscle (Fig. 1)

The patient was transferred to the angiography room for endo-

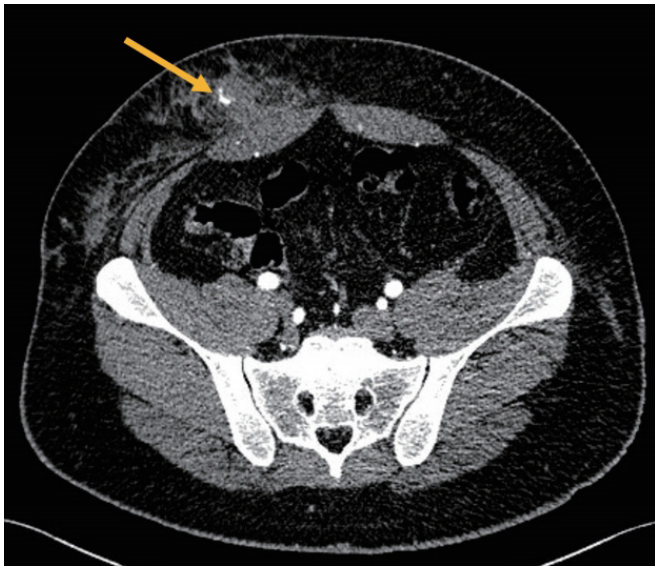

**Fig. 1.** Contrast-enhanced computed tomography showed subcutaneous abdominal contusion with focal active bleeding (arrow).

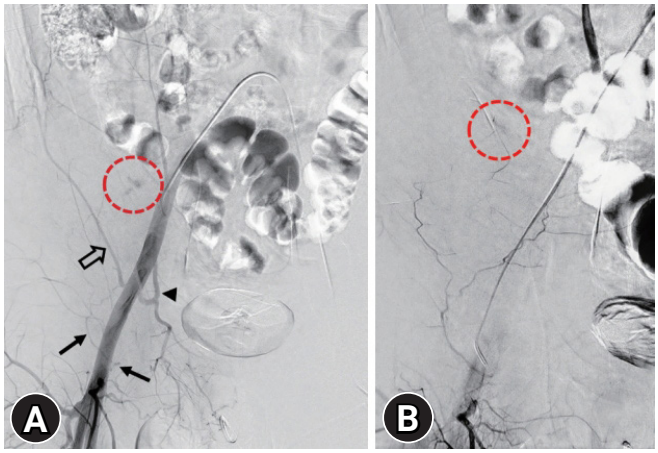


**Fig. 2.** (A) Right external iliac arteriogram revealed focal contrast extravasation (dotted circle), correlated with the findings of the computed tomography scan, and showed several branches, including the deep inferior epigastric artery (arrowhead), deep circumflex iliac artery (open arrow), and superficial inferior epigastric artery (solid arrows). (B) A selective angiogram of superficial inferior epigastric artery showed focal contrast extravasation (dotted circle).

vascular treatment. The initial right external iliac arteriogram showed contrast media extravasation (Fig. 2A), but it was not possible to identify the exact culprit vessel. Therefore, the right deep inferior epigastric artery was selected with a microcatheter and an angiogram was done. Contrast extravasation was not noted on the right deep inferior epigastric angiogram, but empirical embolization was done with gelatin sponge particles. A follow-up right external iliac arteriogram showed continuing contrast media extravasation. To find the injury site, an additional selective angiogram was needed. A deep circumflex iliac arteriogram revealed no active bleeding. A secondary selective angiogram was then done for the small branch arising from the medial aspect of the common femoral artery, showing contrast extravasation (Fig. 2B). Embolization was performed for this vessel, the SIEA.

On the 4th hospital day, follow-up computed tomography showed improvement of the abdominal wall contusion without active bleeding (Fig. 3). He was discharged without any complications on that day. The Institutional Review Board waived the requirement for obtaining informed consent due to the retrospective nature of this research.

**Fig. 3.** On the 4th hospital day, follow-up computed tomography showed improvement of the abdominal wall contusion without active bleeding.

## DISCUSSION

Blunt trauma can cause various abdominal wall injuries, including contusion, hematoma, traumatic abdominal wall hernia, and Morel-Lavallée lesions, which are closed degloving injuries. It is common for patients to present with AWH [1].

In recent years, the growing number of elderly patients and the increasing exposure of the population to risk factors for hemorrhage such as anticoagulation therapy and chronic hepatopathy have made AWH both more frequent and more dangerous [3]. Medically uncontrolled AWH is an indication for surgical or intravascular intervention to prevent worsening outcomes. Endovascular therapies involving embolization of the injured arteries for hemorrhage control have become a rapid and efficient treatment option, decreasing the morbidity and mortality rates [3,4].

When performing endovascular treatment for AWH, clini-

cians must be familiar with the vascular system of the anterior abdominal wall. Most cases of AWH involve rectus sheath hematoma, caused by bleeding from the deep inferior epigastric artery. In these cases, the exact bleeding site is the subcutaneous layer of the anterior abdominal wall. The blood supply to the subcutaneous layer of the anterior abdominal wall is variable, but is mainly from the SIEA [5]. In 1975, Taylor et al. [6] described the anatomy of the SIEA. In most people, the SIEA arises from the common femoral artery approximately 1 cm below the inguinal ligament and ascends in front of the rectus sheath. In approximately one-third of people, the SIEA shares a common origin with the superficial circumflex iliac artery; in another third, the two arteries have separate origins; and in the remaining third, the SIEA is absent [6–8]. After 2010s, as the SIEA flap became more frequently used in plastic and reconstructive surgery, the anatomy of SIEA was more extensively researched using computed tomography images. Several studies reported that the SIEA most commonly has an independent origin from the common femoral artery [8]. In this case, the angiogram showed an independent origin of the SIEA.

In this case, the patient had no significant medical diseases or medication history, and also showed no significant abnormalities on laboratory tests. However, after embolization, the follow-up hemoglobin level decreased by about 2 g/dL. He did not have any other bleeding focus, excluding AWH. We concluded that endovascular embolization for AWH minimized the drop in hemoglobin and reduced potential complications. Transarterial embolization in patients with traumatic AWH who have active bleeding or do not respond to medical treatment is a safe and effective treatment option, but understanding the configuration of the vascular system prior to the procedure is essential.

## NOTES

### Ethical statements

The Institutional Review Board waived the requirement for obtaining informed consent due to the retrospective nature of this research.

### Conflicts of interest

The authors have no conflicts of interest to declare.

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### Author contributions

Conceptualization: all authors; Data curation: all authors; Formal analysis: all authors; Investigation: all authors; Methodology: all authors; Project administration: all authors; Resources: all authors; Software: all authors; Supervision: all authors; Validation: all authors; Visualization: all authors; Writing–original draft: all authors; Writing–review & editing: all authors.
All authors read and approved the final manuscript.

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Case Report

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# Penetrating sacral injury with a metallic pipe: a case report and literature review

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Other than gunshot injuries, sacral penetrating injuries with a foreign body exiting to the other side are extremely rare. We encountered a case of sacral injury in which a long metallic pipe penetrated from the anus into the lower back of a patient. Since the pelvis contains various organs, management of a penetrating injury requires multidisciplinary treatment involving several medical specialties. Due to the infrequency of this type of injury, there are no definitive guidelines for effective management. We described our experience surgically treating a sacral penetrating injury and conducted a literature review. On this basis, we suggest a surgical strategy for treating this type of injury.

**Keywords:** Sacrum; Spinal fractures; Penetrating wounds; Anal canal; Case report

## INTRODUCTION

Penetrating injuries such as stabbing and impalement constitute approximately 0.3% of all spinal cord injuries according to the National Spinal Cord Injury Database, and impalement with a metallic foreign body accounts for only a small proportion of such injuries [1,2]. Penetrating injuries through the torso vary widely depending on the strength of the material. In particular, penetration by a metallic material can strongly impact the bony structure and cause fractures. Surgical treatment for a sacral penetrating injury is difficult due to the anatomical complexity the region and possible combinations of injuries depending on factors such as the foreign object's material, the trajectory of the foreign object, damage to internal organs and blood vessels, infection, cerebrospinal fluid leakage, and neurological problems.

We encountered a case involving a sacral penetrating injury through the anus into the lower back, which was treated successfully. Here, we describe our surgical experience, present a literature review, and suggest strategies for managing sacral penetrating injuries.

## CASE REPORT

An 81-year-old male patient who was hospitalized in a nursing hospital was transferred to Pusan National University Hospital. The patient presented with a metallic pipe that pierced through his anus into the lower back of the iliac crest level about 1 hour before admission (Fig. 1). There were no other witnesses of the accident, and the patient stated that he fell in an attempted suicide and was accidentally impaled with an iron pipe. However,

**Fig. 1.** The patient was placed in a prone position on the operation table. A metallic pipe pierced his anus through to the lower back of the iliac crest level.

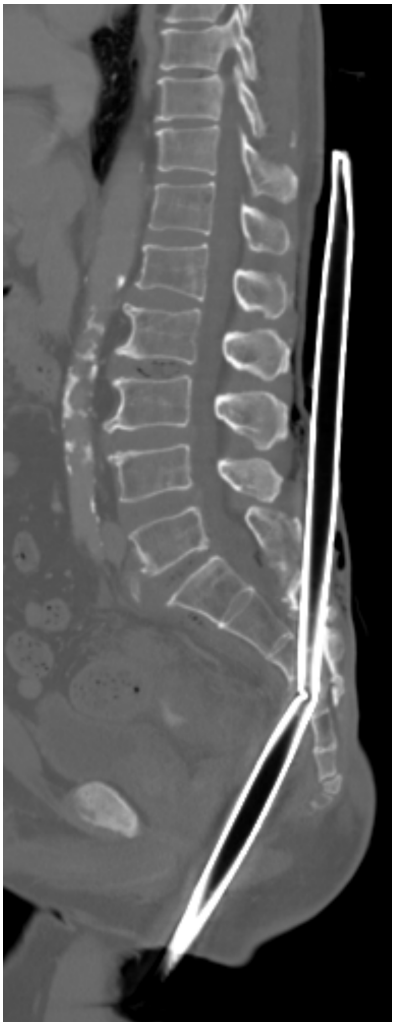

**Fig. 2.** The computed tomography scan showed that the metallic pipe was bent upward inside the sacrum, penetrated the lamina of the second sacrum, and exited through the skin at the level of the fourth lumbar vertebra.

the patient could not describe the accident precisely. He patient had been undergoing treatment for depression and had mild cognitive impairment. During the initial physical examination, the patient's vital signs were stable and laboratory findings were within the normal range, including the hemoglobin level, platelet count, prothrombin time, and activated partial thromboplastin time. Anal tone and reflex could not be determined because of the foreign body, but no other neurologic deficits were identified. A contrast-enhanced computed tomography (CT) scan was performed to accurately examine the internal damage. The CT scan showed that the foreign body entered the anus, perforated the rectum, and entered the body of the fourth right sacral vertebra. The metallic pipe was bent upward inside the sacrum, penetrated the lamina of the second sacrum, and exited through the skin at the level of the fourth lumbar (Fig. 2). Urinary bladder retention was also confirmed. Hematoma and an active bleeding focus were also observed on the right lateral side of the mesorectal area (Fig. 3). Tetanus vaccination and empirical antibiotics were administered, and the patient was then taken to the operating room. A combination of 2 g of cefotetan and 500 mg of metronidazole via intravenous injection was administered.

Our team of neurosurgeons performed an emergency collaborative surgery in combination with the general surgery team. The patient was placed prone on a Wilson table under general anesthesia. The CT scan revealed a bent pipe within the sacral bone, which prevented closed removal. We determined that laminectomy and removal of bony fragments should be the top priority in order to remove the pipe. Routine preparation and drape were performed on the skin and the protruding pipe. A midline skin


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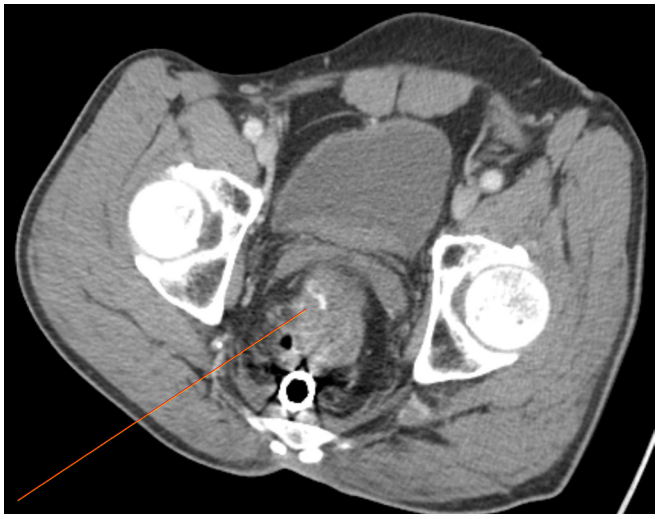

**Fig. 3.** Urinary bladder retention, hematoma, and an active bleeding focus at the right lateral side of the mesorectal area (red line) were revealed on a contrast-enhanced computed tomography scan.

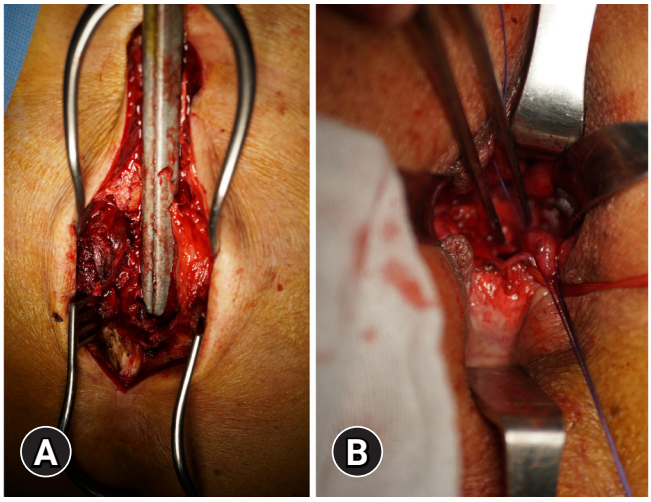


**Fig. 4.** View of operation field. (A) After a midline skin incision, dissection of the subcutaneous tissue and muscle was performed, and the foreign body and sacrum were exposed. (B) The general surgery team sutured the injured anorectal region through the anus.

incision was made from the puncture site of the foreign body to the sacral hiatus. Following dissection of the subcutaneous tissue and muscle, the foreign body and sacrum were exposed (Fig. 4A). We found multiple sacral fractures around the foreign body without cerebrospinal fluid (CSF) leakage. The fractured lamina and bone fragments were removed. Removal of the pipe in one piece increased the risk of bleeding in the visually obscured areas of the penetrating area. Therefore, packing was required for the hematoma and active bleeding focus in the mesorectal area identified in the CT scan. A hole was made using a high-speed drill at the end of the cranial part of the pipe. The hole was connected to a bundle of gauze with a tagging suture. To prevent contamination from bowel contents, the pipe was removed toward the anus by the general surgery team. After removing the foreign body, the tagged bundle of gauze was packed in the mesorectal area. It was confirmed that there was no active bleeding along the packed gauze, and the gauze packed along the trajectory was slowly removed. The pipe was approximately 24 cm long. We observed multiple fractures and injuries to the sacral nerve root from S2 to S4 and the rectum. Right hemilaminectomy of S3, S4, and S5 was performed (Fig. 5). The general surgery team sutured the injured anorectal region through the anus and performed a colostomy (Fig. 4B). No significant bleeding or CSF leakage was detected. The wound was irrigated massively with normal saline. A drain catheter was inserted and the wound was closed layer by layer. There were no specific neurological issues involving motor or sensory function of the lower leg after surgery. The patient was transferred to the intensive care unit after

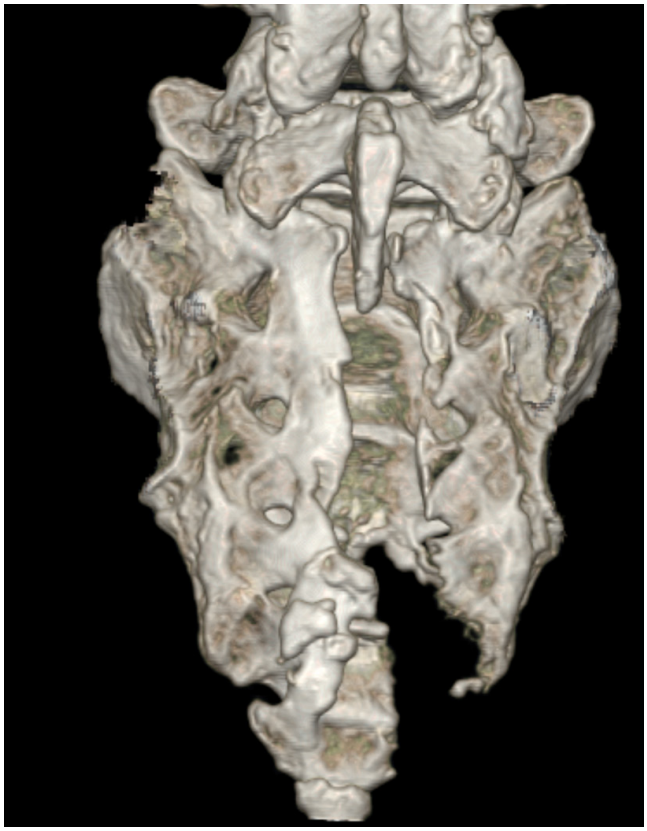

**Fig. 5.** On a computed tomography performed immediately after surgery, total removal of the fractured bone fragments and additional hemilaminectomy were shown.

surgery, and the neurological findings remained unchanged and were similar to the patient's presurgical condition. Sphincter

electromyography could not be performed due to the sutured anal wound.

Antibiotics (500 mg of metronidazole and 2 g of ceftriaxone per day) were administered to the patient intravenously until the 9th day after surgery. The patient's vital signs were stable without any specific problems on the third day of hospitalization, and the patient was transferred to the general ward. Wound care was terminated, and the patient was discharged on hospital day 13 to a nursing hospital. The Foley catheter was removed 2 weeks after the injury following a consultation with the urology department, and the colostomy required further management. The patient visited the outpatient department on the 22nd day after the injury. Colostomy function was normal without any specific symptoms such as a fever or pain. However, the patient was not able to urinate and had not recovered his anal sphincter tone. The study was approved by the Institutional Review Board of Pusan National University Hospital (No. 2103-008-100). Informed consent for publication of the research details and clinical images was obtained from the patient.

## DISCUSSION

An extensive PubMed search of studies published in the English language found only two cases involving a penetrating injury due to a metallic foreign body piercing through the spine and exiting the body. One similar case involved a penetration injury with a steel rod [3,4]. A PubMed search returned seven cases involving penetrating injuries due to a metallic foreign body stuck in the spine without emerging from the body (Tables 1, 2) [1,3–10]. Although rare, sacral penetrating injuries by foreign bodies, such as nails from nail guns, glass, wood, or metal, have been reported [6]. Likewise, anal penetrating injuries, although uncommon, have also been reported. There were no other cases of a metallic pipe causing a penetrating injury through the anus, rectum, sacrum, and skin. Due to the rarity of this type of injury, there are currently no established guidelines for management or treatment. Therefore, we reviewed similar cases and discussed management strategies below.

### Mechanism of sacral penetrating injuries

As shown in Table 1, sacral penetrating injuries are mostly caused by falls (nine of 10 cases) [1,3–10]. Such injuries require enough energy to penetrate the body and trigger bone fractures. The trajectory of the foreign object influences whether it completely penetrates the body. If the trajectory is somewhat parallel or oblique to the vertebral body, the velocity of the for-

**Table 1.** Cases reported in published studies of diagnosed sacral perforating injuries

| Study | Age (yr) | Sex | Mechanism | Kind of foreign body | Entry–exit points | Involved spinal levels | Neurological examination | Accompanying organ damage | Timing of removal |
|---|---|---|---|---|---|---|---|---|---|
| Tokushige et al. (2000) [5] | 66 | Male | Fall | Steel rod | Perianal–none | L5–S1 | Left lower paralysis | Rectum | At the accident site |
| Schildhauer et al. (2005) [6] | 15 | Female | Fall | Steel rod | Perianal–none | S1–5 | Cauda equina syndrome, absent anal tone, perineal sensation | - | NS |
| Serletis et al. (2005) [7] | 6 | Female | Fall | Metallic plant stand | Right buttock–none | S2 | Intact | Vaginal wall, rectum | At the accident site |
| Wang et al. (2009) [8] | 30 | Male | Fall | Steel rod | Right buttock–none | L5–S1 | Intact | Rectum | laparotomy at OR |
| Ritchie et al. (2011) [4] | 28 | Male | In car TA | Metallic pole | Left groin–lower back | S1–2 | Intact | Rectosigmoid | Before laparotomy at OR |
| Zhou et al. (2011) [9] | 37 | Male | Fall | Steel rod | Anus–none | L4–S2 | Paraparesis, urinary retention, decreased perianal sensation | Rectum | At the accident site |
| Tan et al. (2012) [10] | 32 | Male | Fall | Steel rod | Perineum–none | T12–S1 | T9 paraplegia | Rectum | NS |
| Ozaydın et al. (2018) [3] | 11 | Male | Fall | Steel rod | Anus–lower back | S2–5 | Intact | - | After Laparotomy at OR |
| Sarica et al. (2019) [1] | 37 | Male | Fall | Steel rod | Perineum–none | L4–S1 | Left lower extremity paralysis | Rectum | Before laparotomy at OR |
| This case (2021) | 81 | Male | Fall | Metallic pipe | Anus–lower back | S2–S4 | Urinary retention, absent anal tone | Rectum | After laminectomy at OR |

This table is a summary of information before the removal of the foreign body.
NS, not specified; OR, operating room; TA, traffic accident.


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**Table 2.** Cases reported in published studies of diagnosed sacral perforating injuries

| Study | Injured nerve | CSF leakage | Operation | Complication | Voiding | Defecation | Outcome |
|---|---|---|---|---|---|---|---|
| Tokushige et al. (2000) [5] | L5 root | Yes | Laparotomy, proctostomy, laminectomy L4, 5, S1 (simultaneous) | Wound infection, presacral abscess, sepsis | NS | NS | Death |
| Schildhauer et al. (2005) [6] | Sacral plexus between S3 and S4 | No | Laparotomy, laminectomy, reduction, S4 root reanastomosis<br>Posterior fusion (staged, 3 day) | - | Intact | Intact | Right heel numbness trace weakness of the right plantar flexion |
| Serletis et al. (2005) [7] | - | No | Colostomy | - | Intact | Intact | Complete recovery |
| Wang et al. (2009) [8] | - | No | Laparotomy, colostomy | - | Intact | Intact | Complete recovery |
| Ritchie et al. (2011) [4] | - | No | Laparotomy, Hartmann's procedure | Bowel entrapment | Intact | Intact | Complete recovery |
| Zhou et al. (2011) [9] | - | Yes | Laparotomy, colostomy, laminectomy<br>Posterior fusion (staged, 2 mo) | Rectal infection, rectal CSF fistula | No control | NS | Improved muscle strength |
| Tan et al. (2012) [10] | - | No | Laparotomy, colostomy, laminectomy (simultaneous) | Epidural abscess, fistula between vertebral canal and rectum | No control | No control | No improvement |
| Ozaydın et al. (2018) [3] | - | No | Laparotomy | - | Intact | Intact | Complete recovery |
| Sarica et al. (2018) [1] | - | Yes | Laparotomy, colostomy, laminectomy<br>Posterior fusion (staged, 14 hr) | - | Intact | Intact | No improvement |
| This case (2021) | Sacral plexus S2 | No | Laminectomy, laparotomy, colostomy (simultaneous) | - | No control | No control | No improvement |

This table provides a summary of information after the removal of the foreign body.
CSF, cerebrospinal fluid; NS, not specified.

eign object will slow down and stop within the bony structures. However, if the angle of the foreign object is approximately perpendicular to the bony structures, the object will exit the body after penetration. Cases illustrating this mechanism are very rare. In order to remove the object without additional injuries, the trajectory should be determined using radiological findings. A foreign object that is bent by the bone like the one found in our case is very difficult to remove and may warrantlaminectomy.

In the case of a fall-induced penetration injury, the medical professional treating the injury must also evaluate blunt trauma involving other organs during the physical examination and radiological examination. While our case involved an accident sustained due to a fall, there was no blunt trauma involving any body parts other than the area surrounding the trajectory of penetration, possibly due to sufficient deceleration as the foreign object crashed and bent within the bony structure.

## Accompanying injuries

A patient with a penetrating injury to the torso involving a metallic foreign body should be evaluated for severe trauma [1,11]. The sacrum is located in the pelvis, which contains organs such as the bladder, uterus, vagina, and rectum. It also contains complex vascular structures such as the inferior mesenteric artery, the iliac artery originating from the descending aorta, and the venous plexus. A CT scan must be performed with contrast medium to assess the trajectory of the foreign body and injury to the internal organs, major vessels, bony structures, and active bleeding focus [12]. Eight out of 10 of the cases investigated in the literature review involved sustained concomitant organ damage, and the rectum was the most commonly involved intestinal area. One case involved vaginal damage, and the patient recovered with conservative treatment. Sacral injury can trigger damage to the internal thecal sac and the nerves. Thus, a comprehensive neurological examination is also needed [13]. Nerve injury was observed and laminectomy was performed for nerve decompression in three cases. In one of the cases, nerve anastomosis was also performed. CSF leakage was confirmed in three cases, and death due to sepsis was reported in one case. Repair and spinal fusion operations were staged in two cases. Therefore, if a patient with a sacral penetrating injury presents to the hospital, the accompanying structural damage should be confirmed via a thorough radiological investigation and physical examination. Multidisciplinary treatment is essential and depends on the damaged structure.

## Management and surgical strategy for sacral penetrating injuries

Management at the site of the accident is very important for patients with injuries that penetrate the body. Paramedics should avoid causing additional damage at the injury site when changing the patient's body position or removing the foreign body. If the foreign body is too long to be transported, it must be cut to an appropriate length [3]. Such patients should be transported immediately to a hospital with a high-level trauma center where multidisciplinary care is available.

Before removal of the foreign body, the metallic foreign body must be cut to an appropriate size to avoid additional injury. The two types of cutting tools include scissors and spiral instruments. If a spiral-type cutter is used, cold water should be sprayed to prevent burns to patients caused by the conduction of heat during cutting. This method could also trigger an explosion in the operating room if a mixture of oxygen and nitrous oxide comes in contact with a flame or a high temperature [3]. Penetrating foreign substances must be removed surgically using accurate surgical procedures [1]. If a CT scan confirms an absence of major vessel injuries or active bleeding foci, a closed removal may be attempted. If the foreign body is removed prior to surgery, it is easier to accommodate the patient's position. In addition, contamination can be avoided using sterilized drapes. If closed removal is impossible, open removal should be performed. Although ensuring an appropriate patient posture can be difficult and there is a risk of contamination, open removal can be controlled with active bleeding, visual confirmation of the involved organs, and immediate spinal canal decompression.

The purpose of neurosurgical treatment is decompression of the spinal cord, removal of bony fragments and remnants of the foreign body, and the prevention of CSF leakage. Failure to remove any remaining pieces of the foreign body from the penetrated wound may result in CSF leakage, infection, and progressive neurological deficits. If a foreign body is not easily removed due to the bony structures, laminectomy should be performed and bone fragments should be removed to prevent additional injuries to internal organs, blood vessels, and nerves. A fusion operation should also be considered in cases involving severe fractures and a high degree of instability. A fusion operation was performed in three out of 10 the investigated cases, and the procedure was performed in stages according to the risk of infection. Stabilization of the bony structures should be considered in the event of an injury at the level of the lumbo-sacral junction.

We further analyzed two issues related to treatment for the patient involved in our case. The first issue concerned additional infection by the patient's bowel contents. We thoroughly performed drape and irrigation of the metallic pipe. In addition, the foreign body was pulled out in the anal direction followed by a colostomy. The second issue was the presence of hematoma and an active bleeding focus on the right lateral side of the mesorectal area identified on the CT scan. Control of the active bleeding was considered a significant challenge because of the narrow and long wound trajectory. Therefore, packing was necessary along the penetrating wound. A hole was made in the upper end of the pipe using a high-speed drill. We connected the hole and the bundle of gauze. The pipe was pulled out in the anal direction along with the gauze, and the penetrated wound was packed with gauze. We successfully treated the injury without causing infection or massive bleeding using the two steps described above.

## Prognosis

Sacral penetrating injuries are associated with a risk of several complications due to the location of adjacent organs. Tetanus vaccination and appropriate antibiotics should be administered to the patient. In the case of penetration injury by metallic foreign bodies, infection is a major challenge. Sarica et al. [1], who examined several steel rod impalement injuries involving the spine, found that five out of 10 cases were followed by infection. The degree of infection covered a wide spectrum and included wound infection, abscess, sepsis, and death. Penetrating injuries can involve multiple body parts, ranging from the skin to the abdominal cavity, the retroperitoneal cavity, the intestines, and the central nervous system, and broad-spectrum antibiotics should therefore be used. Recommendations for broad-spectrum antibiotics have been explored in another study [14], particularly related to bowel perforation. The specific selection of antibiotics and their uses were different for each reported case. In general, antibiotics to treat skin flora and intestinal bacteria that pass through the blood-brain barrier were selected and administered. A stoma should be placed after a colorectal injury is identified. Eight out of 10 cases involved colorectal injuries, and a stoma was placed to treat patients in each of these cases. Of the 10 patients with sacral penetrating injuries we investigated, three cases resulted in infections, and one of the patients with an infection died due to sepsis.

In five out of 10 cases, deterioration of the motor and sensory functions was observed in the initial evaluation. One patient died of sepsis, and neurological recovery could not be confirmed. All of the patients underwent laminectomy for decompression. No improvement was detected in two cases, and partial improvement was observed in two cases. Urinary retention


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as well as an absence of anal tone were observed in the initial evaluation in four out of the 10 cases. The patient subsequently lost the ability to control voiding and defecation in three out of the 10 cases. The patient's sacral plexus between the S3 and S4 levels was damaged in one recovered case, and the patient underwent laminectomy and reanastomosis. For the patients involved in the remaining three cases and our case, the sacral plexus was severely damaged. This is because the pelvic splanchnic autonomic nerve that runs from the S2 to S4 root regulates bladder and anal functions [15]. In one case, the steel rod penetrated through the sacral bone into the spinal canal at the T12 level, and complete damage occurred to the conus medullaris. In another case, fractures from L4 to S2 after anal penetration led to cauda equina syndrome. Therefore, the degree to which the nerves are affected by a penetration injury should be examined thoroughly, and in addition to sacral plexus injury, conus medullaris syndrome and cauda equina syndrome should also be considered. Therefore, sufficient decompression should be undertaken. Although it was not attempted in most cases, nerve reanastomosis may also be considered.

Our case involved surgical treatment of a sacral penetrating injury caused by a metallic pipe. More particularly, the reported penetrating injury was through the anus, rectum, sacrum, and lower back. Since sacral penetrating injury is generally accompanied by organ damage due to the anatomical location, a careful examination of accompanying pelvic organ injuries such as rectum and vascular system injuries along with a suitable surgical method are required. In particular, multidisciplinary treatment is recommended to safely remove the foreign body and minimize complications and neurological sequelae.

## NOTES

### Ethical statements

The study was approved by the Institutional Review Board of Pusan National University Hospital (No. 2103-008-100). Informed consent for publication of the research details and clinical images was obtained from the patient.

### Conflicts of interest

The authors have no conflicts of interest to declare.

### Funding

None.

### Author contributions

Conceptualization: IHH; Data curation: MH; Formal analysis: MH; Methodology: IHH, KHN, JHK; Writing–original draft: MH; Writing–review & editing: all authors.
All authors read and approved the final manuscript.

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Case Report

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# Acute pyomyositis of the adductor magnus muscle involving the posterior and lateral thigh compartments: a case report of diagnosis and management

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Bacterial infection of skeletal muscle can lead to the formation of abscesses. Primary pyomyositis is typically seen in tropical countries, and *Staphylococcus aureus* is the commonest causative organism. We present a case of acute adductor magnus muscle abscess (pyomyositis) with spread to adjacent thigh compartments via the perforators without iliopsoas muscle involvement. Due to the involvement of the entire thigh compartment, systemic antibiotic treatment alone was insufficient, whereas surgical drainage improved the clinical picture. The aetiological organism was *S. aureus*. Herein, we report the case of a patient who had primary pyomyositis, rather than a secondary type, that spread to the posterior and lateral aspect of the thigh through the second and third perforators, which pierce the adductor magnus muscle belly before entering the femur.

**Keywords:** Pyomyositis; Abscess; Debridement; Washout; Case report

## INTRODUCTION

We present a case of acute adductor magnus muscle abscess (pyomyositis) with spread to adjacent thigh compartments via perforators without iliopsoas muscle involvement. We also discuss the differential diagnosis and principles of management.

## CASE REPORT

A 59-year-old male patient presented to the emergency department with sepsis in the evening. The clinical examination noted left thigh pain associated with reduced movement and left lower leg swelling. The patient reported nontraumatic, sudden-onset left thigh pain and swelling, with a reduced range of movement in the hip/knee and inability to bear weight. On examination, he had a palpable swelling over the medial aspect of the left proximal thigh and a skin induration over the lateral aspect. His body temperature was 38.9°C, he had hypotension, and he showed confusion with facial flushing. He had a background of multiple sclerosis and autoimmune skin conditions, and he was on long-term high-dose prednisolone. On radiographs of the left thigh, soft tissue shadows were noted, and a complete blood count showed an elevated white cell count and a C-reactive protein (CRP) level of 625 mg/L. The differential diagnoses were iliopsoas abscess with spread to the adductor muscles and necrotising fasciitis. Blood cultures were taken, the patient was resuscitated with fluids, a urinary catheter was inserted, the intensive treatment unit team was involved, and the patient was kept nil by

mouth and was sent for an urgent computed tomography (CT) scan of the left hip/thigh and pelvis to confirm the diagnosis. The CT scan showed multiple pockets of intramuscular abscesses in the belly of the adductor magnus muscle; no iliopsoas abscess or any communication with the iliopsoas was noted (Figs. 1–3). The CT scan did not show any collection of pus in the posterior and lateral thigh compartments. Due to the patient's high temperature and very high CRP levels, a decision was made to take the patient to the emergency operating room on the same evening/night, and the patient was placed on the emergency operating room list. The patient and his next of kin received an explanation about the patient's clinical status, laboratory results, the CT scan report (Figs. 1, 2), and the planned surgery (exploration and drainage of the collection).

A direct medial approach was performed posterior to the adductor longus, and the adductor magnus muscle belly was approached (Fig. 4). Blunt dissection revealed an intramuscular pus collection (approximately 50 mL) that was sent for an urgent microbiological examination (Gram stain, culture, and sensitivity). Even though the CT scan did not show any collection, the skin induration over the lateral aspect of the thigh prompted us to

**Fig. 1.** Thigh computed tomography (axial section).


**Fig. 2.** Thigh computed tomography (coronal section).

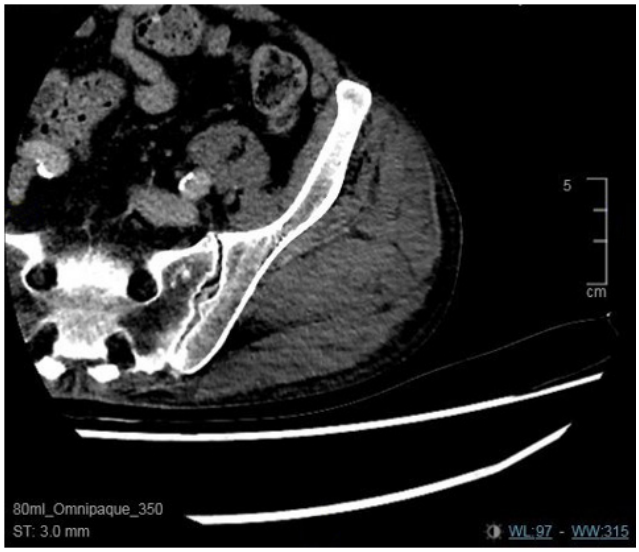


**Fig. 3.** Axial section of pelvic computed tomography.

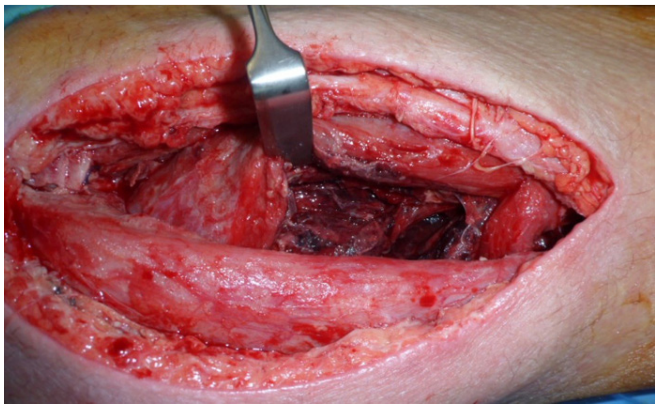

**Fig. 4.** Adductor magnus belly.


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perform needle aspiration, which showed frank pus. Approximately 10 mL of pus collection was noted around the adductor magnus muscle attachment with the femur and tracked to the anterolateral aspect of the thigh, which was approached using two direct lateral incisions, as marked in Fig. 5, and approximately 20 mL of pus was drained (Fig. 6). The spread from the adductor magnus muscle to the posterior and lateral compartments of the thigh was explained by the anatomy of the second and third perforators piercing the adductor magnus muscle before entering the femur (Fig. 7).

A thorough washout was done and a vacuum dressing was applied (Fig. 8). The pus was sent for a microbiological examination. The Gram stain, culture, and sensitivity test showed *Staphylococcus* growth with sensitivity to flucloxacillin and metronidazole. Serial CRP examinations showed marked reductions in CRP levels, and the patient demonstrated clear clinical improvement. After four episodes of exploration and debridement, the wounds were closed (Fig. 9). Antibiotics were given intravenously during the hospital stay, a peripherally inserted central catheter line was inserted, and the patient was later discharged home with intravenous ceftriaxone (2 g, once a day) and oral metronidazole for 2 weeks.

The patient showed consistent improvement and the wounds healed well. The patient was followed up until it was confirmed that he had recovered well. Written informed consent was ob-

**Fig. 5.** Two lateral incisions.

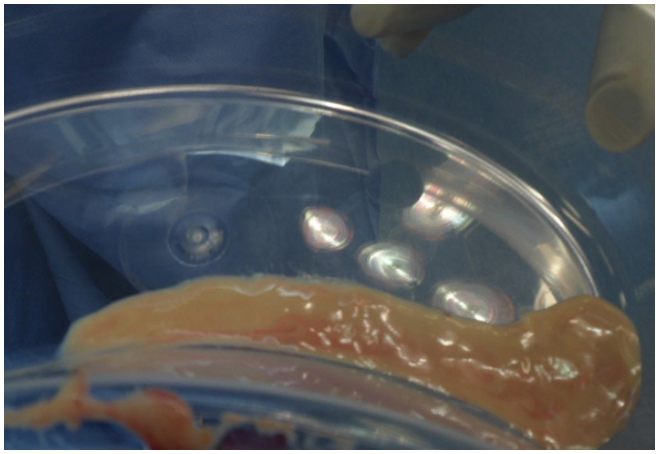

**Fig. 6.** Drained pus.

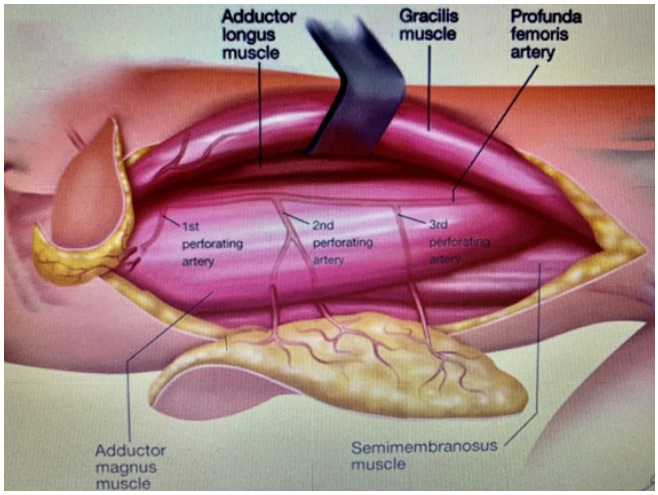


**Fig. 7.** Anatomy of the adductor magnus and perforators.

**Fig. 8.** Vacuum dressing *in situ*.

**Fig. 9.** Photograph taken after wound closure.

tained from the patient for publication of this case report and any accompanying images.

## DISCUSSION

Acute, isolated, spontaneous-onset adductor muscle abscesses are uncommon, as adductor muscle abscesses usually spread from the iliopsoas. The spread of infection to the posterior and lateral aspects of the thigh in this case is explained by the infection tracking along the second and third perforators, which pierce the adductor magnus muscle belly before entering the femur. The aetiology of acute muscle abscess is usually secondary to trauma, which is often trivial. Diabetes mellitus, steroid treatment, and immunodeficiency have been identified as predisposing factors [1]. In our case report, the patient was on long-term, high-dose oral prednisolone, which was the relevant predisposing factor. The clinical presentation of isolated adductor muscle abscess is variable and non-specific. Pyomyositis is relatively more common in children, and has an equal sex distribution. In rare cases, psoas abscesses can extend to the adductors [2]. Acute primary abscess or polymyositis is rare in the western world [3], and is more prevalent in tropical countries. Muscle abscesses secondary to intramuscular injections have been reported [4]. *Staphylococcus aureus* is the bacterium that is most commonly responsible for pyomyositis and was the responsible bacterium in our case. Other less commonly seen bacteria are group A streptococci and *Staphylococcus pneumoniae*. Unusual bacterial species include *Escherichia coli, Salmonella typhi, Bacteroides fragilis, Neisseria gonorrhoeae*, and *Mycobacterium tuberculosis*, and in some rare cases, muscle abscesses can be caused by fungal, parasitic, and viral agents [5].

The diagnosis of muscle abscess is often difficult, and the differential diagnosis includes muscle strain, synovitis, tumour, septic arthritis, fracture secondary to trauma, osteomyelitis, inflammatory arthritis (rheumatoid arthritis, gout, psoriatic arthritis), and osteoarthritis. The clinical examination findings include a palpable mass, erythema, localised tenderness, reduced limb/joint movements, and associated low-grade fever, while rare complications include peripheral nerve palsy [6]. Our case report showed all of the above clinical findings except nerve palsy. The laboratory findings include raised white cell count and CRP levels, which were also noted in our case report. The blood cultures are usually positive and radiological investigations are the mainstay of diagnosis and treatment. Plain radiographs may show a soft tissue shadow, but a contrast CT scan, magnetic resonance imaging, or a gallium scan can show the underlying abscess findings [7,8]. The treatment of muscle abscess is drainage with the administration of intravenous antibiotics selected on the basis of culture and antibiotic sensitivity testing. Isolated adductor magnus muscle abscesses are uncommon, although they have been described with pathogens such as *M. tuberculosis* [9]. This case report highlights the importance of considering tuberculosis in the differential diagnosis of any unexplained soft tissue swelling in endemic areas. In our case report, the CT scan did not show any collection of pus in the posterior and lateral thigh compartments, or any communication with the iliopsoas muscle. The skin induration over the lateral aspect of the thigh prompted us to perform needle aspiration, which showed frank pus; based on this finding, we performed exploration and washout. With prompt diagnosis and management, a full recovery can be achieved with an excellent prognosis.

The abscess in this patient was large and loculated inside the adductor magnus belly and its attachment with the femur. It spread to the posterior and lateral compartments of the thigh via the perforators, which pierce the adductor magnus muscle. A CT scan helped to make a definitive diagnosis and rule out an associated iliopsoas abscess. In this case, the CT scan did not show any collection of pus in the posterior and lateral thigh compartments; however, the skin changes over the lateral aspect of the thigh prompted us to perform needle aspiration, which showed frank pus. This led us to perform exploration and washout. The patient was treated successfully with emergency open surgical drainage and antibiotic therapy. Primary muscle abscess is a rare condition, but must be considered as a cause of leg/thigh/hip pain. We recommend a prompt clinical diagnosis with the use of imaging


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modalities, and urgent surgical exploration of suspected areas is the key to treat muscle abscesses.

## NOTES

### Ethical statements

Informed consent for publication of the research details and clinical images was obtained from the patient.

### Conflicts of interest

The authors have no conflicts of interest to declare.

### Funding

None.

### Author contributions

Conceptualization: RB; Data curation: JW, KY; Project administration: RB, JW; Writing–original draft: RB; Writing–review & editing: RB, DP, BS.
All authors read and approved the final copy of the manuscript.

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# Instructions for Authors

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## MANUSCRIPT PREPARATION

Manuscripts should be written in English. Medical terminology should conform to the most recent edition of Dorland's Illustrated Medical Dictionary.

### General Principles

- Word processors and format of manuscript: Manuscripts

should be submitted in the file format of Microsoft Word 2010 or higher. Manuscripts should be typed on an A4-sized document, be double-spaced, and use a font size of 10–12 point with margins of 2 cm on each side and 3 cm for the upper and lower ends. We recommend the use of the template provided at https://www.jtraumainj.org/authors/authors.php for formatting the manuscript.

- Abbreviation of terminology: Abbreviations should be avoided as much as possible. One word should not be expressed through an abbreviation, although two or more words may be expressed through an abbreviation. The full term for which the abbreviation stands should be used at its first occurrence in the text. Abbreviations should not be present in the title. Common abbreviations, however, may be used, such as DNA, COVID-19.
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## Organization of Manuscript: Original Articles

*1. Arrangement of the manuscript:* Original articles should be organized in the order of Title page, Abstract & Keywords, Main text (Introduction, Methods, Results, Discussion), References, Table, Figure, and Figure Legends. The title of each new section should begin on a new page. Number pages consecutively, beginning with the abstract page. Page numbers should be placed at the middle of the bottom of each page.

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- A maximum of 5 keywords should be listed, immediately after the abstract. Each keyword should be separated by a semicolon (;). The authors should use MeSH (Medical Subject Heading) terms in their keywords (https://meshb.nlm.nih.gov/).

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- Discussion: Discussion should emphasize the new and important aspects of the study, including the conclusions. Do not repeat the results in detail or other information that is included in the Introduction or Results sections. Describe the conclusions according to the purpose of the study but avoid unqualified statements that are not adequately supported by the data. Conclusions may be stated briefly in the last paragraph of the Discussion section.

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- References should be obviously related to the document. In the text, references should be cited with Arabic numerals in brackets, numbered in the order cited. In the references section, the references should be numbered and listed in order of appearance in the text.
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- In principle, references should be limited to 30 in original articles.
- The description of the References section is provided below. The References follow the NLM Style Guide for Authors, Editors, and Publishers (http://www.nlm.nih.gov/citingmedicine) if not specified below.

• Sample


1. Yeo KH, Park CY, Kim HH. Abdomino-perineal organ injuries caused by cultivators. J Trauma Inj 2015;28:60–6.
2. Mattox KL, Moore EE, Feliciano DV. Trauma. 7th ed. New York: McGraw Hill; 2013.
3. Burlew CC, Moore EE. Emergency department thoracotomy. In: Mattox KL, Moore EE, Feliciano DV, editors. Trauma. 7th ed. New York: McGraw Hill; 2013. p. 236–50.
4. World Health Organization (WHO). WHO statistical information system [Internet]. Geneva: WHO; 2021 [cited 2021 Feb 1]. Available from: https://www.who.int/workforcealliance/knowledge/resources/whosis/en/.
5. Sharma N, Sharma P, Basu S, et al. The seroprevalence and trends of SARS-CoV-2 in Delhi, India: a repeated population-based seroepidemiological study [Preprint]. Posted 2020 Dec 14. medRxiv 2020.12.13.20248123. https://doi.org/10.1101/2020.12.13.20248123.


*6. Tables*

Tables must be numbered in the order in which they are cited in the text. Each table must be simple and typed on a separate page. Supply a brief title at the top of the table. The titles of tables start with "Table 1." Footnotes should be provided consecutively in order of the information, statistics, and abbreviations. Footnoted information should be referenced using superscript small letters (e.g., a, b) in alphabetical order.

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Authors must submit figures and illustrations as electronic files. Images must be provided as TIFF files. JPEG is also acceptable when it is the original format. Each figure must be of good quality, higher than 300 dpi resolution with good contrast and sharpness. Figures must be sized to 4 inches. If possible, submit the original file without any modifications.

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*8. Legends of Figures*

All figures should be described in the text separately. The description order must be the same as in the footnotes in tables and should be in recognizable sentences. In microscopic pictures, staining methods and magnification ratio should be indicated.

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1. The Editorial Board requests review articles of particular titles and text. The author can describe text that is not itemized.
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3. In principle, references should be limited to 100 in reviews.

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1. Case reports describe unique and instructive cases that make an important teaching point or scientific observation, novel techniques, use of new equipment, or new information on diseases that are of importance to the critical care field.
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   - Case report: Describe only the clinical findings and management steps that are directly related to critical care.
   - Discussion: Briefly discuss the case and state conclusions at the end of the case. Do not structure the conclusion section separately.
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## Organization of Manuscript: Others

Other publication types such as Editorial, Guidelines, Correspondence, and Brief reports, may be accepted. The recommended format can be discussed with the Editorial Board.

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- ☐ The abstract should be included in the manuscript, regardless of whether it is included in the submission system.
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