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Case Report

Case series report: simultaneous internal fixation of multiple fractures

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ABSTRACT

Background: Polytrauma is often associated with a high mortality rate and requires intensive management. Although several cases of polytrauma have been reported as being related to thoracic or brain injury, there are few reports concerning multiple fractures. We aimed to present a case series report about polytrauma with multiple fractures, highlighting several clinical importance and management strategies. **Case presentation**: The first case is a 31-year-old male patient who was admitted to the emergency department with multiple injuries from violent abuse, including intraperitoneal bladder rupture, right pulmonary contusion, bilateral closed femoral shaft fractures, bilateral closed humeral shaft fractures, and bilateral closed radius and ulna shaft fractures. Case 2 is a 41-year-old female who was involved in a motorcycle accident in a head collision, with multiple wounds and multiple fractures, including the right distal third radius, ulna, 2nd metacarpal, right distal third tibia, and fibula. The last case is a 25-year-old comatose male patient who was hospitalized with several wounds and bruises on the right lower extremity and left forearm after a traffic accident. He was diagnosed with a concussion, crush wound of the right foot with metatarsal fractures, and a closed fracture of the right middle third femur, right middle third tibia, and left distal third radius. Three cases of multiple trauma were reported, in which we successfully internally fixed four to eight fractures at once without any complications after the procedure. The patient's wound status at admission, such as whether they have an open fracture or a complex wound that could become infected and result in sepsis or hemorrhagic shock, should be a crucial factor considered when deciding whether to perform emergency orthopedic surgery. Additionally, patients who have been properly stabilized and do not have any concomitant conditions or concurrent soft tissue injuries can receive early total care. Patient awareness is a critical sign for serial CT brain scans and additional surveillance before definitive fracture fixation. **Conclusion**: This report can serve as a reference for management decisions in future instances within the context of national healthcare capacity.

Key words: multitrauma, polytrauma, multiple fracture, internal fixation, early total care, damage control orthopaedics

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INTRODUCTION

Polytrauma is a term used to describe severely injured patients or those with multiple injuries. The definition of polytrauma has evolved since it was first introduced to refer to a condition consisting of at least 2 significant injuries of 2 different organ systems, with 1 of these being potentially life-threatening, and involving both anatomical injuries and physiologic disturbances[1]. The Berlin definition is the most recent and consists of the following: a patient with an abbreviated injury scale score ≥ 3 for 2 or more different body regions with an additional 1 or more variables from 5 physiologic parameters, including systolic blood pressure ≤ 90 mm Hg, Glasgow Coma Scale score ≤ 8, base excess ≤ 60, international normalized ratio ≥ 1.4 or partial thromboplastin time ≥ 40 s, and age ≥ 70 years[1]. The most common causes of polytrauma include traffic accidents, falls from heights, and bullet and improvised explosive device injuries[2]. The causes of death in patients with polytrauma are predominantly central nervous system injury (21.6 – 71.5%), followed by severe blood loss (12.5 – 26.6%), sepsis (3.1 — 17%), and multi-organ failure (1.6 — 9%)[3]. In addition to mechanical damage causing organ dysfunction, a myriad of pathophysiological processes occur in a polytraumatized patient whose body's systemic equilibrium has been perturbed, including the triad of death: coagulopathy, hypothermia, and metabolic acidosis[4]. Uncontrolled hemorrhage depletes intravascular volume and the number of clotting factors and platelets, which subsequently degrades intrinsic hemostasis. Hypoperfusion results from blood loss and vascular leakage in response to

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an acute inflammatory process that engenders septic or hypovolemic shock and consequent lactic acidosis from the tissue's anaerobic respiration. Additionally, patients with polytrauma are vulnerable to many pathogens and late complications due to their compromised integumentary defense and immunity.

The abovementioned dysregulations of the body require prompt, ordered, and adequate intervention to resuscitate the patient and prevent potentially life-threatening conditions. Polytrauma is associated with a mortality rate higher than that expected from the sum of the separate injuries and thus demands more intensive care[5]. Therefore, comprehensive care in polytrauma should consist of both medical and surgical management as well as interdepartmental collaboration involving emergency physicians, neurosurgeons, thoracic surgeons, orthopedic surgeons, general surgeons, urologists, and anesthesiologists.

After hemorrhagic control is achieved, initial resuscitation and the applicable prioritized procedures, such as thoracocentesis or decompressive craniectomy, bone fixation, and limb-saving, are considered. However, there has been increasing concern regarding orthopedic approaches, including the timing and types of surgery[6–8].

Several cases of polytrauma have been reported to be related to thoracic injuries[9–12] or brain and spinal cord injury[13,14]. However, to the best of our knowledge, few case reports have discussed how multiple fractures are managed in polytrauma; therefore, we present our experience in managing 3 cases of polytrauma at a primary healthcare facility, in which we performed internal fixation of 4 to 8 fractures simultaneously. Given the absence of studies on clinical decision-making concerning the timing and types of orthopedic surgery for polytrauma among the Vietnamese population, this report can serve as a basic reference for the choice of management in future cases within the context of the national healthcare capacity.

CASE PRESENTATION

Case 1

A 31-year-old male patient was admitted to the emergency department with multiple injuries from violent abuse, including intraperitoneal bladder rupture, right pulmonary contusion, bilateral closed femoral shaft fractures, bilateral closed humeral shaft fractures, and bilateral closed radius and ulna shaft fractures. Right upper extremity palsy was found. At the time of admission, the patient was conscious with a 13-15 Glasgow Coma Scale score, a pulse of 85 beats/minute, a blood pressure of 75/40 mmHg with a palpable radius and dorsalis pedis pulse, and an SpO_2 of 95%.

The prioritized problem in the patient was hemorrhagic shock from polytrauma, and he was resuscitated with normal saline and blood transfusion, oxygen therapy, and extremity-splinting while being administered intravenous analgesics before appropriate surgical correction could be applied. Interdepartmental consultation was initiated, and the patient subsequently underwent emergency surgery to suture the bladder and indwell the urinary catheter.

A day later, the patient was successfully stabilized with a pulse of 98 beats/minute, a blood pressure of 140/70 mmHg, and an SpO_2 of 99%. After consultation between the orthopedics and anesthesia departments, a decision to definitively fixate 8 broken bones simultaneously under general anesthesia was made. The middle right femur was broken transversely (32A3b according to the AO classification), and the middle left femur had an intact wedge fracture (32B2b). The other broken bones of the right upper extremities were classified as 12A3b, 2R2C2j, and 2U2A2a, while those of the left upper extremities were classified as 12A3b, 2R2A3b, and 2U2A3b.

Both femurs were approached first to prevent further blood loss and exacerbated insults to soft tissue due to large bone fragments. One locking plate and eight screws were used for right femur fixation (**Figure 1a**), while one locking plate and nine screws, including one lag screw, were used for the left femur (**Figure 1 b**). The entire process took 2 hours and 20 minutes.

For the left humerus, surgeons used 1 locking plate plus 6 screws for fixation (**Figure 1b**). Second, we treated the radius with an anterior (Henry) approach and reduced the fracture using internal fixation with 2 straight plates and locking screws (**Figure 3b**). Third, as the left ulna had a diagnosis of 2U2A2a, we used a Kirchner wire for fixation based on the fracture's pattern (**Figure 3b**). On the right side, a similar approach was applied with 1 plate and 6 locking screws to fix the humerus (**Figure 2a**). A straight plate and locking screws were used to fix both the right radius and ulna fracture (**Figure 3 a**). The surgery for the upper part was completed in 3 hours.

After surgery, the patient was hemodynamically stable and immobilized with a long leg and long arm splint. Aggressive and early rehabilitation was implemented to improve muscle strength, proprioception, and range of motion (ROM), as well as reduce pain and swelling. A continuous passive motion device was used for the evaluation of the contraction of

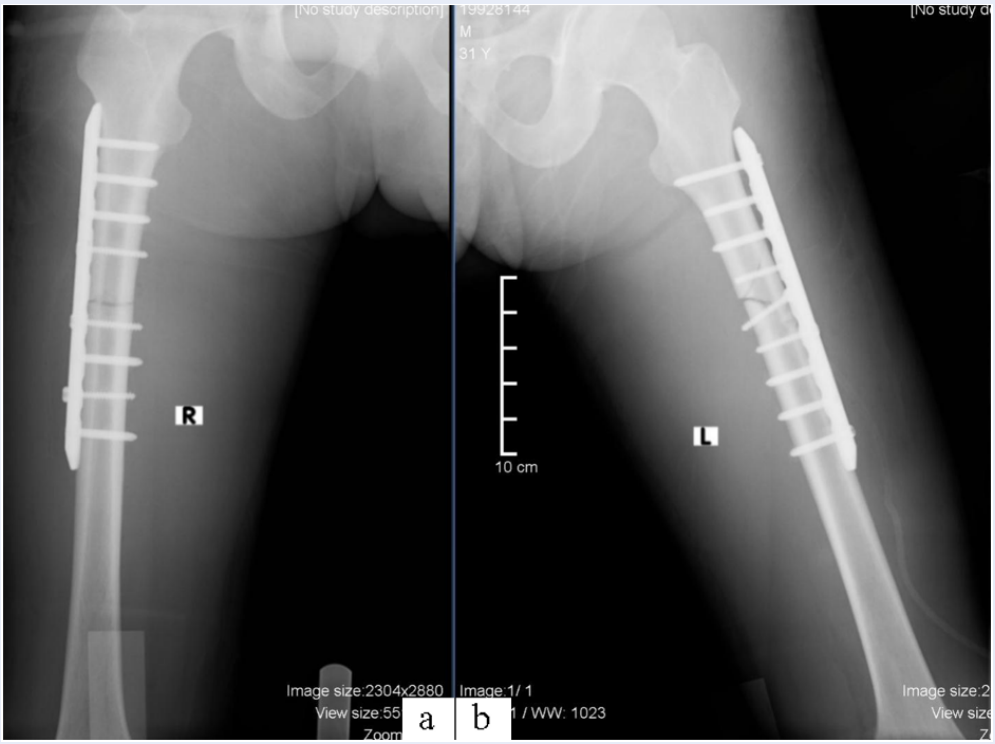

Figure 1: **Case 1 X-ray of the femur after surgery**. (**a)** X-ray of the right femur after internal fixation with plate and screws. (**b)** X-ray of the left femur after internal fixation with plate and screws (lag screw).

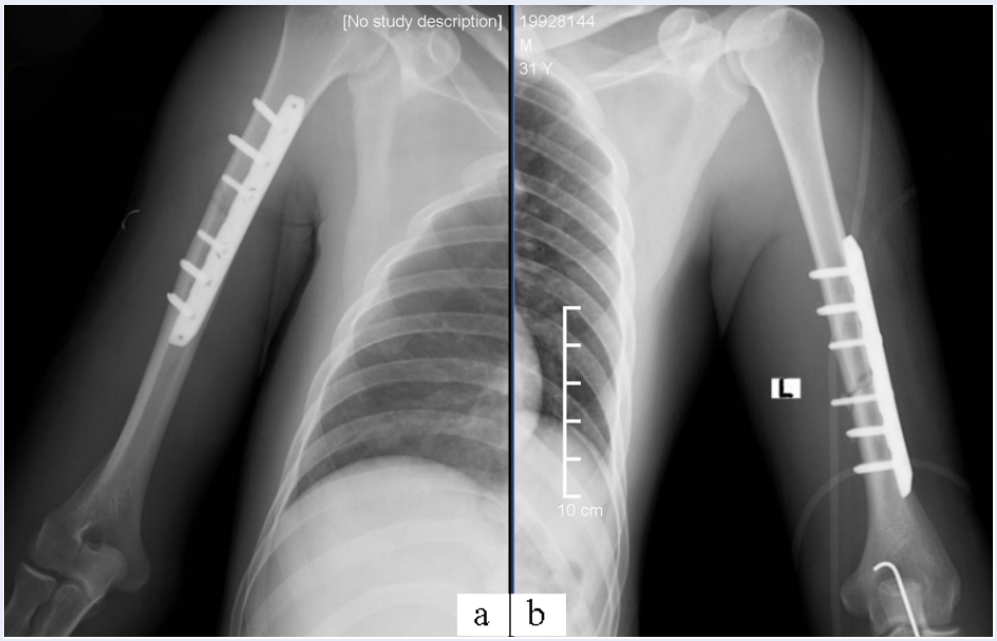

Figure 2: **Case 1 X-ray of the humerus after surgery**. (**a)** X-ray of the right humerus after internal fixation with plate and screws. (**b**) X-ray of the left humerus after internal fixation with plate and screws.

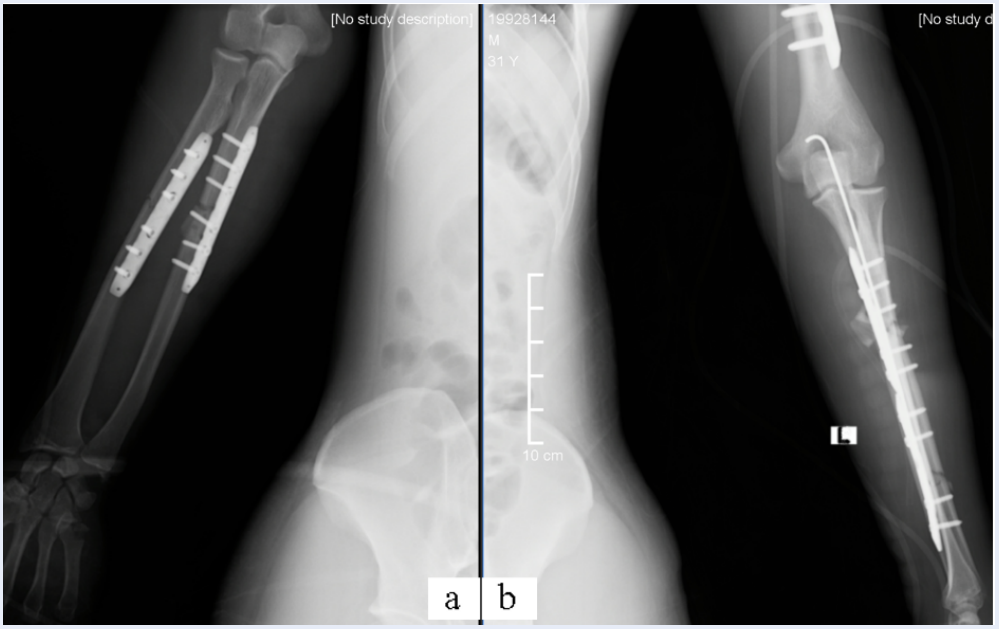

Figure 3: **Case 1 X-ray of the radius and ulna after surgery**. (**a**) X-ray of the right radius and ulna after internal fixation with plate and screws. (**b**) The left radius was fixed with 2 straight plates and locking screws, and the left ulna was fixed with Kirchner wire.

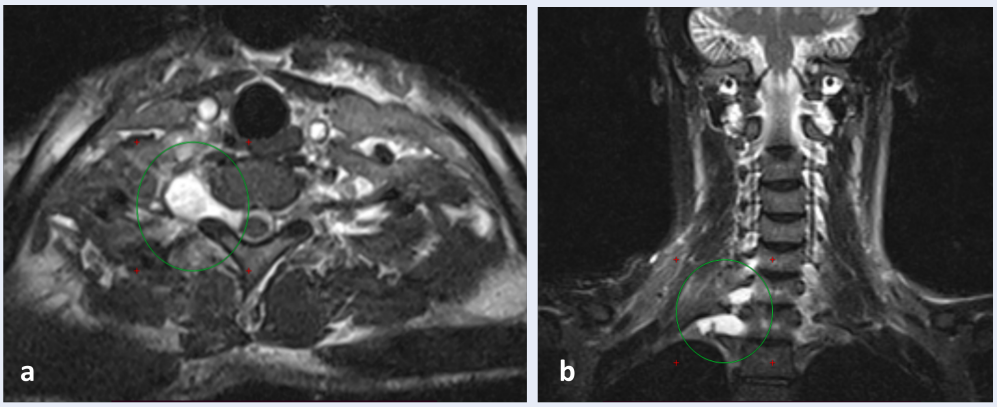

Figure 4: **Case 1 cervical magnetic resonance imaging**. (**a**) T2-weighted axial, and (**b**) T2-weighted sagittal oblique imaging at the C6-7 and C7-T1 level lost the nerve root signal and was replaced by a fluid signal.

the quadriceps muscle and knee ROM. Physical therapy was applied to maintain appropriate movements and ROM of the shoulder joints. A cervical magnetic resonance imaging examination was performed to evaluate upper extremity palsy. Before hospitalization, a right upper injury was defined as a cervical injury (**Figure 4**). A urinary catheter was removed from the patient 15 days postoperatively, and he was discharged from the hospital after 20 days.

Case 2

A 41-year-old female was involved in a motorcycle accident in a head collision and was admitted to the emergency department with a 10 × 3 cm (length × width) wound on the right lower leg, a 1 × 1 cm wound on the right forearm, and a 2 × 1 cm wound on the dorsal side of the right hand. X-ray showed 2R2A2c, 2U2A2c, 42B3c, 4F2c, and 77.3.2 fractures according to the AO classification (**Figure 5**). A head computed tomography (CT) scan appeared normal.

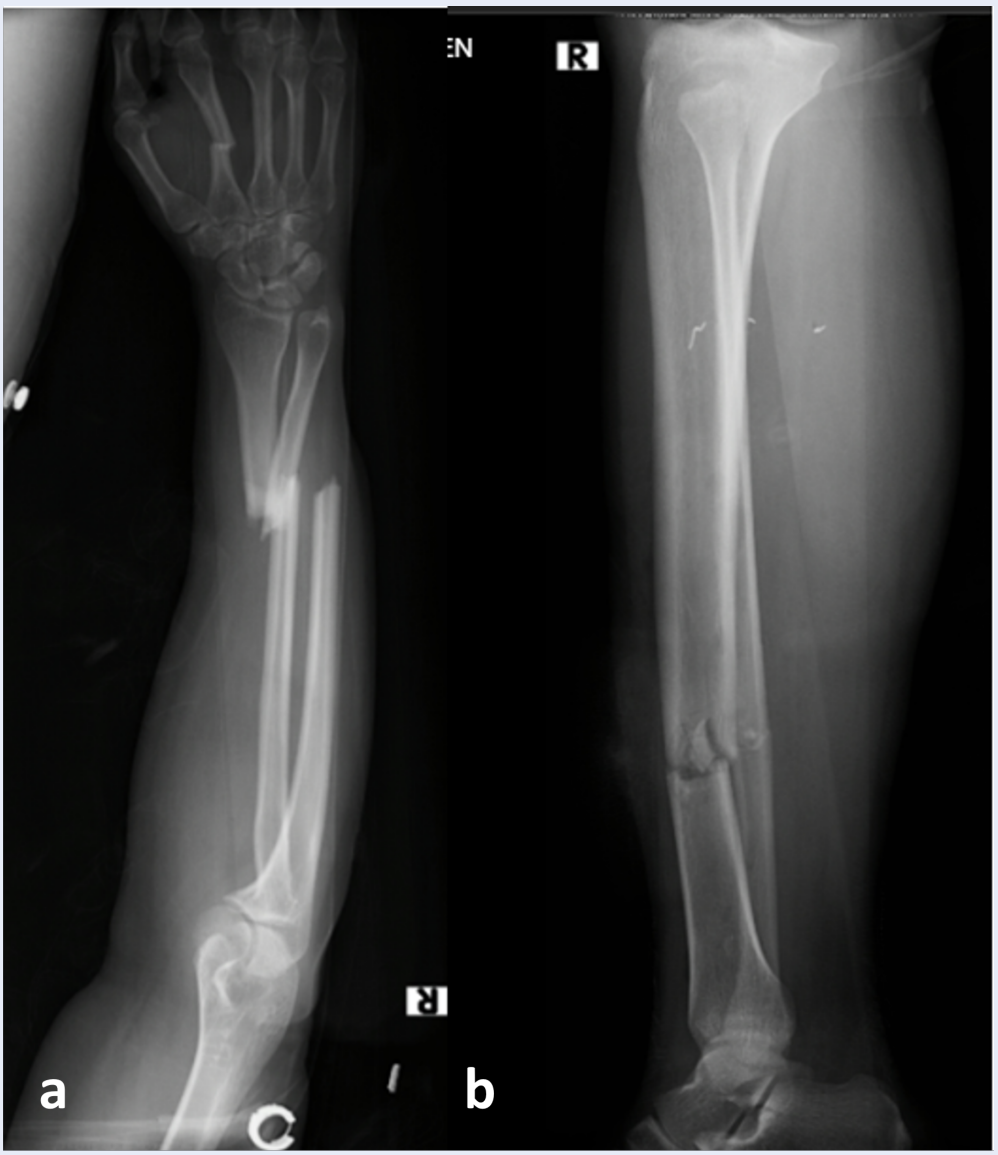

Figure 5: **Case 2 X-ray upon admission**. (**a**) Right displaced distal third radius, ulna, and 2nd metacarpal shaft fracture. (**b**) Right displaced distal third tibia and fibula fracture.

She was diagnosed with a grade IIIA open fracture of the right tibia and fibula (according to Gustilo-Anderson Classification), a grade I open fracture of the right ulna and radius, and an open fracture of the right second metacarpal. The patient was immobilized with a Zimmer splint and a long arm splint. Her wound was also sterilized with betadine and covered with gauze pads as she awaited surgery.

The patient's open fracture indicated emergency orthopedic surgical correction. The surgery was performed 6 hours after hospitalization under general anesthesia by 3 surgeons. First, a definitive synthesis for the tibia was made with a Φ9 mm × 30 cm Mediox tibial nail and 4 locking screws. Second, the radius was treated with a 9 cm anterior (Henry) approach, and the fracture was reduced via internal fixation with an 8-hole straight plate and 6 locking screws. Third, we approached the ulna with a 6-cm-long skin incision that ran parallel to the ulnar crest and applied a 7-hole straight plate and 6 locking screws to fix the ulna fracture. Finally, the second metacarpal fracture was reduced and fixed with a 6-hole straight plate and

Figure 6: **Case 2 surgical incisions at day 10 post-operative showed appropriate skin healing, without any signs of complications or infection**.

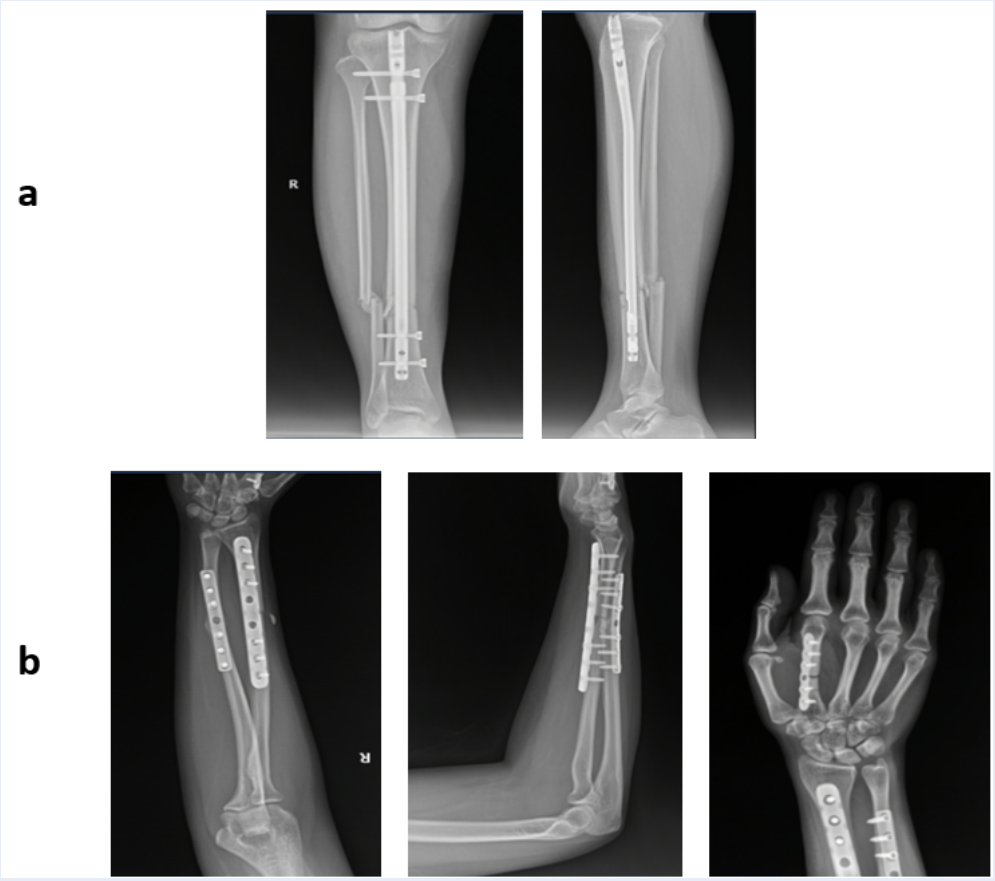

Figure 7: **Case 2 X-ray 2 months post-op**. (**a**) Right tibia shaft fixation using an intramedullary nail and four locking screws. (**b**) Right radial, ulnar, and second metacarpal shaft fixation using plates and screws.

5 screws through a dorsal hand incision (**Figures 6 and 7**). The surgery lasted 2 hours. The patient's postoperative care was uneventful, and she was discharged after 14 days.

Case 3

A 25-year-old comatose male patient was hospitalized with several wounds and bruises of the right lower extremity and left forearm after a traffic accident. Upon admission, the patient was unconscious with a 7-15 Glasgow Coma Scale score, a pulse of 92 beats/minute, a blood pressure of 140/80 mmHg with palpable dorsalis pedis and radial pulse, and an SpO_2 of 98%. The dorsum of the right foot had a crush wound 20 × 12 cm (length × width) in size with jagged borders. The wound was contaminated with many foreign bodies, and there was necrosis of the second and third phalanges, open dislocation of the first phalanx, and open fracture of the fifth metatarsal.

The patient was first resuscitated with an 8 l/m oxygen mask with a reservoir bag and fluid and blood transfusion; moreover, immobilization with a foothold Zimmer splint and forearm-hand splint, clean gauze bandage of the right foot, and intravenous analgesics were applied before surgery. At 2 hours after admission, the patient remained comatose with a pulse of 110 beats/minute and a blood pressure of 110/70 mmHg. His head CT scan showed no remarkable lesions. The patient was diagnosed with a concussion, crush wound of the right foot, and a closed fracture of the right middle third femur (30B3), right middle third tibia (42B), and left distal third radius (22A2) according to the AO classification (**Figure 8**).

Three hours after hospitalization, emergency surgery was performed for tissue debridement of the right foot, maintenance of the first and fifth phalangeal axes with a piercing "K" wire, amputation of the second and third phalanges, and insertion of a traction pin at the right femur.

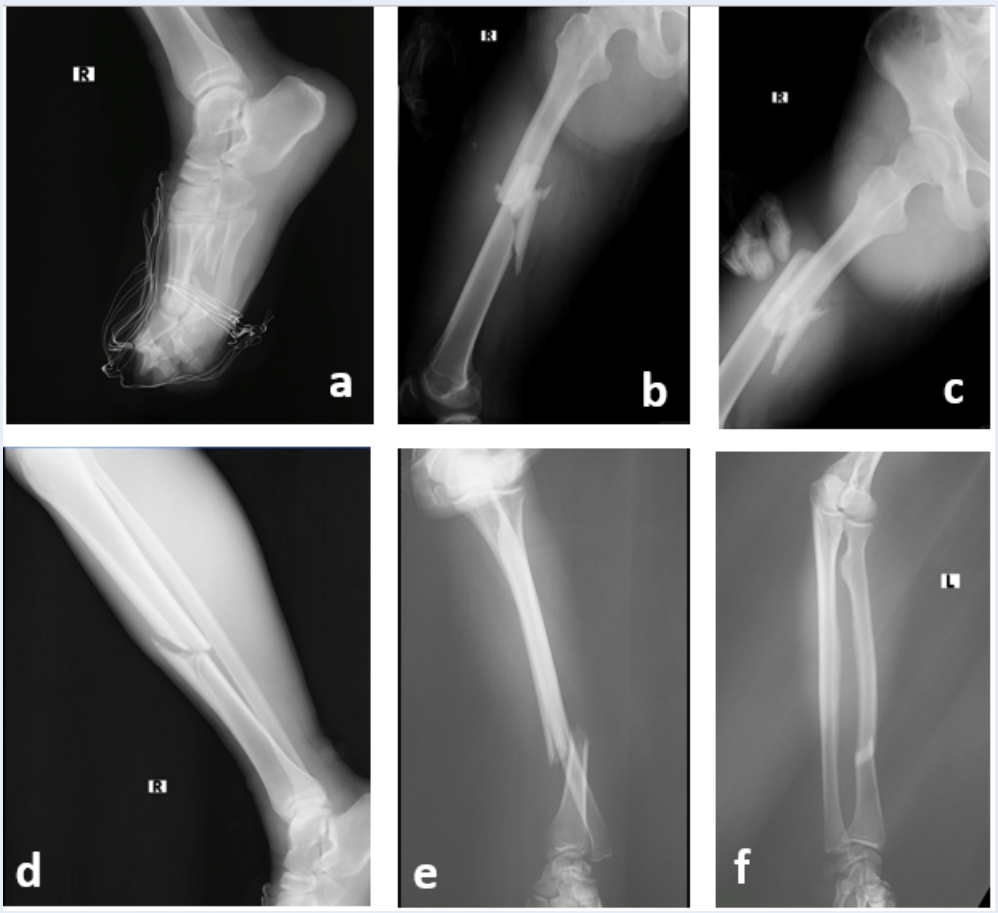

Figure 8: **Case 3 X-ray upon admission**. (**a**) Preoperative X-ray of the right foot with partial amputation of the second and third toes, dislocation of the first toe, and fracture of the fifth metatarsal. (**b,c**) Preoperative X-ray of right femur fracture (30B3). (**d**) X-ray of preoperative right tibia fracture (2B). (**e,f**) Preoperative X-ray of left radius fracture (22A2).

Eleven days later, definitive fixation surgery was performed. First, 2 steel wires were used to fix the greater fragment to the femur shaft, and then 1 locking plate and 9 screws were used for femur fixation. Second, an incision approximately 5 cm in length was made below the kneecap; a split was made along the patellar tendon; the triangle above the tibial tuberosity was determined; the marrow was drilled at a point 1 cm above the tibial tuberosity; the fracture site was reduced, one 9 × 320 mm nail was fixed on the C-arm screen; 2 proximal screws, 2 distal screws, and 1 drain were applied; the incision was sutured; and the gauze bandage was cleaned. Finally, an incision was made on the anterior of his left forearm approximately 7 cm in line with the Henry approach. Dissection revealed that the distal third of the radius was broken, and the fracture was cleaned. The fracture was fixed with 1 locking plate and 6 screws, the fracture site was thoroughly checked, the incision was sutured, and the gauze bandage was cleaned (**Figure 9**). The surgery lasted 3.5 hours from the time of anesthesia until completion. After surgery, the patient was hemodynamically stable. He was discharged from the hospital after 20 days.

Postoperative management

After surgery, the patients continued to receive broad-spectrum antibiotics and a pain-relieving combination of patient-controlled analgesia with tramadol 0.2 g/day, paracetamol IV 3 g/day, and diazepam 5 mg at night 3 days postoperatively before a switch to paracetamol alone. No postoperative complications were recorded. Early rehabilitation was initiated after surgery. First, muscle-strengthening exercises were performed in bed for the first week. Subsequently, for tibial intramedullary nail fixation, the patients could

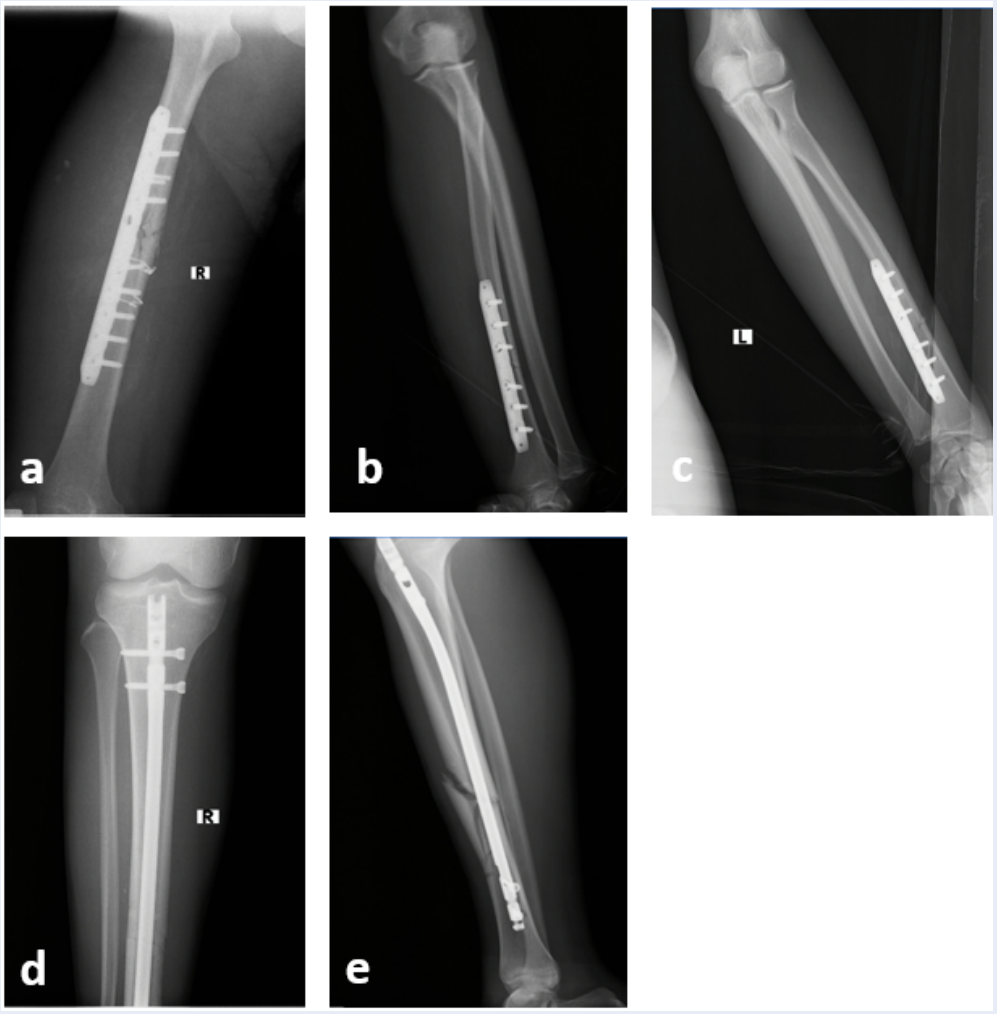

Figure 9: **Case 3 post-op X-ray images**. (**a**) X-ray of the right femur after internal fixation with locking plates and screws. (**b, c**) X-ray of the left radius after internal fixation with locking plates and screws. (**d, e**) X-ray of the right tibia after internal fixation with an intramedullary nail.

apply partial weight-bearing for the second week and begin total free weight-bearing after 4 weeks, and the splint was removed. For femoral plate fixation, the patient was allowed to perform partial weight-bearing after 8 weeks and begin total free weight-bearing after 12 weeks, and the splint was removed. The functional outcome was good at the 6-month follow-up, with patients showing a normal ROM and walking without pain or limp.

DISCUSSION

This case report presents 3 cases of polytrauma with multiple fractures admitted and managed at a Vietnamese central hospital. This report focuses on describing the orthopedic approach, specifically the surgical timing and treatment plan after all initial patient resuscitation had been completed. The principle of initial polytrauma management remained relatively unchanged and included the airway, breathing, circulation, disability, and exposure approach; fluid therapy; and blood transfusion. However, there is an ongoing debate regarding whether early total care (ETC) or damage control orthopedics (DCO) offer greater benefit to patients with polytrauma [15]. Based on the manifestation of shock, coagulopathy, body temperature, and soft tissue injuries, patients with polytrauma are classified into 4 classes: stable, borderline, unstable, and in extremis. DCO is the favored approach for in extremis and unstable patients, while ETC is preferred in stable patients [7]. It is the borderline classification that engenders the most controversy concerning the most suitable approach.

ETC supports early fixation of broken bones to prevent exaggerated physiological stress and stabilize the patient from fracture-related complications, including fat thrombosis, hemorrhagic and vagal shock, sepsis, and acute respiratory distress syndrome (ARDS)[16], particularly in those severely injured or with open fractures. Nalm *et al.* concluded that early fixation within 24 hours is safe in most patients with polytrauma[17]. In another study, adequately resuscitated patients with borderline polytrauma including a long bone fracture or a fracture associated with massive exsanguination (*e.g.*, those of the femur, tibia, or pelvis) but no severe soft tissue injuries were demonstrated to benefit from early (within 4 days) definitive stabilization[18]. A case report indicated that a patient with polytrauma and multiple closed rib fractures and a floating shoulder was successfully treated with early definitive fixation of the clavicle after successful resuscitation and thoracotomy for hemopneumothorax[19]. A different study of 191 patients with femoral shaft fracture, however, showed that those with complicated fractures, including bilateral femur fracture, type 32C fracture, floating knee (combined femoral and tibial fracture), associated femoral neck fracture (bifocal fracture) or traumatic hip dislocation, concomitant femoral artery injury, and/or sciatic nerve injury developed postoperative complications after early intramedullary nailing and subsequently experienced a prolonged hospital stay[20].

On the other hand, the rationale of the DCO approach is that a polytraumatized patient might be too frail to survive a major surgery; thus, temporary external fixation is required until the patient is sufficiently stable to tolerate definitive surgery. As a natural healing response, there is a hypoinflammatory phase following the hyperinflammatory response to serious trauma[21,22]. This biphasic response can, during the hypoinflammatory process, result in increased morbidity. Posttraumatic complications are induced by several secondary endogenous and exogenous variables. Specifically, the iatrogenic second hit might be the consequence of massive transfusions and surgical procedures that exacerbate tissue damage and blood loss[23] or precipitate systemic complications such as sepsis, ARDS, and multiple organ failure in severe patients[21]. In patients with polytrauma involving abdominal injuries, the application of the DCO strategy has been shown to result in better survival rates[24]. Overall, the DCO approach aims to minimize blood loss, sepsis, and ischemia.

The relevant literature suggests that the degree of chest trauma and brain injury, as well as patients' resuscitation status, is critical in determining a suitable approach for treating polytrauma[8,25–27]. In recent years, an approach compromising between DCO and ETC was formalized as early appropriate care, in which experts support the principles of ETC for even severely injured patients after resuscitation is complete[28].

In the present report, the first case was considered unstable since his systolic pressure was below 90 mmHg. He underwent emergency surgery to first control the bladder bleeding. The day after, when he was hemodynamically stable, we decided to perform definitive surgery for all 8 fractures. Stahel *et al.* reported that posttrauma days 2 to 4 are considered inappropriate for definitive surgery[29]. In our case, there were no postoperative complications. This can be explained by the fact that our patients were relatively young and had no comorbidities; moreover, the postoperative complications were well managed by pain reduction, adequate provision of fluid, and early mobilization. Furthermore, the patient responded well to the initial resuscitation and was clinically improved after 24 hours; thus, a definitive surgery, especially of the femoral shaft, could be performed to reduce the risk of blood loss, aid with in-hospital care, and promote the patient's rapid functional recuperation.

The other 2 cases belong to the stable category, but high-grade open fractures were present. Therefore, they were indicated for emergency definitive surgery to prevent systemic infection and osteomyelitis. The second patient's stable condition also favored the ETC approach, whose benefits include faster recovery and shorter hospital stay. The third patient was indicated for immediate surgery because of his complex wound and open fracture of the right foot. His heart rate increased from 92 to 110 beats/minute despite fluid resuscitation. The wound site needed to be cleaned, and several tarsal fractures were corrected to minimize the risk of infection, sepsis, and further bleeding before a larger operation could be performed to fix the other long bone fractures. Furthermore, despite his first CT brain scan appearing normal, an intracerebral injury was still suspected at the time due to his ongoing altered consciousness. After emergency surgery, the patient remained lethargic with stable hemodynamics. His second CT scan revealed bilateral intracerebral hemorrhage of the temporal lobe, which required further monitoring. In the meantime, antirotation bracing was applied for all other closed fractures. During emergency surgery, traction was implemented for the patient's shortening femoral shaft fracture for stabilization and control of pain and hemorrhaging before definitive surgery was performed.

CONCLUSION

We present 3 cases of polytrauma in patients whom we resuscitated and treated with simultaneous internal fixation of 4 to 8 fractures with no postoperative complications. These operations were performed at a central hospital in Vietnam, and each case required 2-3 orthopedic surgeons. The decision for emergency orthopedic surgery should primarily depend on the patient's wound status at the time, for example, whether he or she has an open fracture or complex wound that could be infected and cause sepsis or hemorrhagic shock. Additionally, successfully stabilized patients with no comorbidities or concurrent soft tissue injury can be administered ETC. Intracerebral hemorrhage may occur later after the injury; thus, the patient's consciousness is a vital signal for serial CT brain scans and further monitoring before definitive fracture fixation.

ABBREVIATIONS

ARDS: Acute respiratory distress syndrome, **CT**: Computed tomography, **DCO**: Damage control orthopaedics, **ETC**: Early total care, **ROM**: Range of movement

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None.

AUTHOR'S CONTRIBUTIONS

All authors contributed to the study's conception and design. The first draft of the manuscript was written by Toan Thanh Vo, Kha Dong To, Luc Bao Nguyen, Duc Thien Nguyen and Vien Hoang Ngo. The following versions were modified and edited with further contribution by Thai Hoa Thi Nguyen, Dat Thanh Ha, Ngan Doan and Quang Van Le. All authors read and approved the final manuscript.

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AVAILABILITY OF DATA AND MATERIALS

Data and materials used and/or analyzed during the current study are available from the corresponding author on reasonable request.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval is not required for this study in accordance with local guidelines. Informed consent was obtained from all subjects involved in the study.

CONSENT FOR PUBLICATION

Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

COMPETING INTERESTS

The authors declare that they have no competing interests.

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