Case Report

Closed chest compressions after rib plating

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Introduction

Effective conventional closed chest compressions (CCC) in the treatment of cardiac arrest in adults is associated with sternal and rib fractures. Although rare, these fractures can result in life-threatening injuries such as cardiac laceration and pericardial tamponade (1,2). The popularity of surgical stabilization of rib fractures (SSRF) is on the rise, owing to increasing evidence suggesting its association with improved analgesia, faster return to work, reduced hospital stay, and decreased incidence rates of respiratory failure and pneumonia (3,4). The feasibility and effect of cardiopulmonary resuscitation (CPR) on rib plates are still largely unknown (5). To our knowledge, only one previous case report has discussed the effects of CCC on rib plating where hardware failure occurred (6). We present a patient with rib plates who received successful CCC during multiple cycles of CPR.

Case presentation

This case report was reviewed and approved by our institution's ethical review board. A 54-year-old unrestrained driver was transferred from a local hospital to our level 1 trauma center after driving his car off a cliff. His past medical history included chronic obstructive pulmonary disease, diastolic dysfunction, and myocardial infarction on dual antiplatelet therapy status post bare metal cardiac stent placement 2 years ago. He was evaluated and treated according to Advanced Trauma Life Support®. His injuries along with a comprehensive list of operative interventions are shown in *Table 1*. Of note, he had multiple rib fractures, as shown in *Figure 1*. He was admitted to the surgical intensive care unit and was placed on multimodal analgesia (*Table 1*). The patient was not a candidate for paravertebral or epidural pain catheter insertion because of his antiplatelet therapy. Due to increasing pain and oxygen requirements, non-invasive positive pressure ventilation was required. On hospital day (HD) 3, he underwent bronchoscopy, placement of chest wall pain catheters, and SSRF of right ribs 4–5 and left ribs 5–7 using the Synthes MatrixRIB Fixation System (Synthes, West Chester, PA, USA) (*Figure 2*). On HD 5, he underwent open reduction internal fixation (ORIF) of his right acetabulum and was extubated on HD 6. On HD 8, the patient sustained pulseless electrical activity (PEA) arrest and was treated with CPR for 7 min with ensuing return of spontaneous circulation (ROSC). The cardiac arrest was the result of respiratory failure due to pulmonary embolism, which was confirmed by a subsequent computed tomography (CT). Incidentally, CT images revealed an intact post-CCC SSRF (*Figure 3*). Physical examinations showed no evidence of chest wall instability, clicking, or crepitation. Anticoagulation and diuresis were started, and the patient was extubated to non-invasive positive pressure ventilation on HD 17. Three days later, he went into a second PEA arrest. CPR was performed for 23 min with ROSC. A follow-up chest X-ray to assess intubation demonstrated right lung consolidation and intact SSRF plates (*Figure 4*). Unfortunately, the patient remained in multisystem organ failure with refractory hypotension, and his family elected for comfort measures without escalation of care. The patient expired 20 days after presentation.

Discussion

This case demonstrates that effective CPR after rib plating is possible without prosthetic fracture, periprosthetic

Table 1 Injuries and respective interventions

Injury	Operative intervention
Steering wheel injury	
Right 4–9 anterior RFx; Left anterior 3–9 RFx; Sternal fracture; Right pulmonary contusions	HD 1: multimodal analgesia: (ketamine infusion, pregabalin, hydromorphone patient-controlled anesthesia, celecoxib, lidocaine patch) HD 3: SSRF right ribs 4, 5, and SSRF left ribs 5, 6, 7; placement of chest wall catheters
Right open ankle fracture; Right talar dislocation	HD 1: irrigation and debridement of right ankle, wound closure, and placement of femoral traction pin
	HD 17: irrigation and debridement of right ankle
Right posterior acetabular fracture	HD 1: right femoral head traction
	HD 5: right acetabulum ORIF and removal of femoral traction pin

HD, hospital day; ORIF, open reduction internal fixation; RFx, rib fractures; SSRF, surgical stabilization of rib fractures.

Figure 1 Three-dimensional reconstruction of steering wheel chest injury. Right ribs 4–8 were fractured anteriorly and left ribs 3–8 were fractured anteriorly.

fracture, screw pullout, or other deformation of the reconstructed chest wall.

Key metrics for high-quality CPR according to the American Heart Association include insuring adequate CCC depth and achieving complete chest wall recoil (7). The forces needed for effective compressions put significant

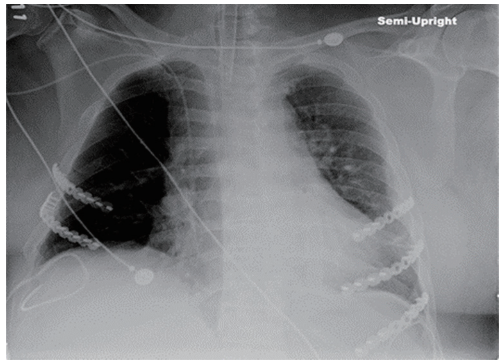

Figure 2 Postoperative chest X-ray illustrating the plating technique used in surgical stabilization of rib fractures.

stress on the rib cage. Skeletal chest injuries from CPR are well documented among individuals without prior rib fractures. The incidence of rib fractures after CPR is reported in over 70% of CPR cases, with a mean number of 7.6 broken ribs per person (8). Despite their rarity, these fractures can result in fatal injuries such as cardiac laceration and pericardial tamponade (1,2). Significant forces required for effective CCC raises the potential concern that a reconstructed chest wall with plate may impede the delivery of chest compressions. Successful CPR implies both ROSC and an uncomplicated neurological recovery (9). Our patient was neurologically intact and achieved ROSC after the first cardiac arrest. Likewise, he had ROSC after the second arrest, but the extent of neurological impairment remains unknown. We conclude that effective CPR is feasible after SSRF.

While SSRF does not appear to impede the delivery of CPR, hardware failure is a legitimate concern due to the application of significant forces to the rib plating system and landing site. For the SSRF hardware to withstand the compressive dynamics of CCC, the implants must be capable of demonstrating both immense strength and dynamic flexibility. Newer systems demonstrated low profile and easier insertion, but achieved the optimal balance of flexibility and strength to mimic normal rib function. Anatomic, pre-contoured plates have been designed and tested to permit not only regular breathing but also to withstand the stress of respiration and other functions of the chest wall. One prospective study following patients that had been treated with the MatrixRIB fixation system found no accounts of hardware failure or loss of initial fixation among 91 rib plates placed at their 6-month follow-up (10). Additionally, the use of bicortical engagement screws

Figure 3 Chest computed tomography image of three-dimensional reconstruction after the first round of cardiopulmonary resuscitation illustrating intact plates.

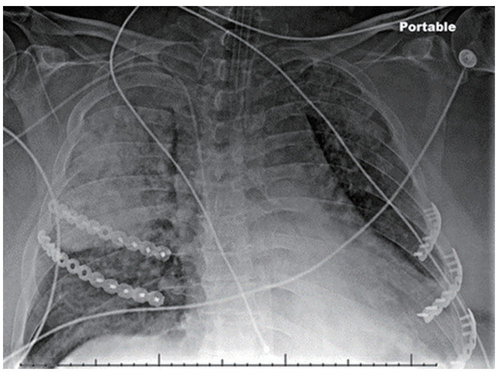

Figure 4 Chest X-ray after the second round of cardiopulmonary resuscitation illustrating no additional rib fractures, intact plates, and absence of screw pullout.

through the chest wall cortex and pleural cortex, along with the threaded screw head that engages in threaded plate holes that lock the screw, confers additional plate security and prevents pullout (11). In fact, an *in vitro* biomechanical study estimated that the combined approach of flexible rib plating with locking screw fixation not only prevents screw loosening and pullout, but can restore up to 77% of the native rib strength (12).

Despite the advances in the rib plating system technology, hardware failure such as screw pullout and additional rib fractures as a result of a single cycle of CPR after SSRF is possible (6). However, our patient experienced neither hardware failure nor additional rib fractures even after receiving multiple extended rounds of CPR at less than 1 week postoperatively. Further reports are needed to elucidate a more delayed effect of CPR on rib plates.

Conclusions

This case report illustrates that rib plates can not only allow effective CPR but also withstand the compressive forces of multiple rounds of CPR without mechanical failure. Further studies are needed to investigate the effects of CPR on rib plates in a larger subset of patients.

Acknowledgements

None.

Footnote

Conflicts of Interest: Marcel Tafen is a paid speaker/presenter for Synthes. The other authors have no conflicts of interest to declare.

Informed Consent: Written informed consent was obtained from the patient's legally authorized representative for publication of this manuscript and any accompanying images.

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