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Rib Osteosynthesis for Sub-Acute Management of a Flail Chest in a Tertiary Centre in a Low-Middle Income Country of Sub-Saharan Africa: Case Report at Douala Laquintinie Hospital

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Abstract

Background: Costal fracture surgical is still a debate, therefore we shall select between early and delay surgical management. **Case Report:** We are reporting two cases of post road traffic clash delay ribs fractures osteosynthesis involving a 63-year-old man with multistage fractures on the left and pulmonary pinning of one of the costal arches, complicated by a homolateral haemothorax and a 41-year-old man with a bilateral flail chest. **Conclusion:** The simple postoperative course and the immediate postoperative improvement in the patient's clinical respiratory condition enabled us to discuss the time frame for management, in this case the indication for early or later surgery.

Keywords

Flail Chest, Fixation Plate, Rib Fracture, Osteosynthesis

1. Introduction

Thoracic injuries are responsible for a relevant number of deaths by contributing to 25% of deaths seen in trauma patients [1]. Also, apart from intrathoracic organs, the sequelae of injuries affect the bony chest wall in particular.

Rib fractures account for 10% of all trauma admissions and carry a heavy burden of morbidity and mortality [2]. Multiple rib fractures are consequence of significant forces impacting the chest wall and are most commonly due to blunt injuries, but penetrating injuries can also fracture ribs. The morbidity from such injuries increases with age, number of fractures, and presence of flail segments. Patients with rib fractures often present with underlining pulmonary contusions, are more susceptible to pneumonia, and have long-term pain and disability [3].

Over the years, different surgical technique and plate systems have been used to stabilize ribs fractures. Regardless the risk of bleeding and infection, most surgical approaches have shown superiority compared to conservative treatment in regard to hospital stay, time with mechanical ventilation and risk of pneumonia. However, there are few data supporting one technique over another [4]. Also, therapeutic strategies vary according to the topography of the fracture lines, the anatomical type of flail chest, and the association with other intra-thoracic lesions.

We report two cases of patients treated surgically in our department for closed chest trauma following road traffic accidents, all complicated by rib fractures.

2. Cases Description

2.1. Case 1

This is a 41-year-old man polytrauma patient without a relevant past medical history who presented to the emergency unit of Douala Laquintinie Hospital (DLH) after sustaining both a lower limb and a chest trauma following a road traffic clash. He was a passenger on a motor bike which had a head-on collision with a touristic car resulting on his propulsion with reception on his left side of his body. On admission, he was haemodynamically stable with good oxygen saturation. The clinical exam revealed: chest tenderness on ribs palpation on the left without asynchronous thoracic movement and inability to mobilise the left lower limb.

The paraclinical workup showed:

- Chest radiograph (anteroposterior view): Left non-displaced lateral border ribs fracture from the 4^{th} to 7^{th} ribs.
- Thighs radiographs (anteroposterior view): Fractures of both proximal femurs.
- Preoperative workup including Full blood count (FBC) and Coagulation profile were normal.

After an anaesthesiologic consultation he underwent a close reduction and internal fixation of his femoral fracture via an intramedullary nailing.

Concerning the rib fracture, following an initial conservative management the progress on 64th post-osteosynthesis day was mark by a sudden onset orthopnoea, spontaneous chest pain and respiratory distress with an oxygen saturation of 82% on ambient air prompting an urgent chest radiograph request which revealed a massive compressing haemothorax. A complementary Chest scan confirmed a Left massive compressing haemothorax, the lateral border of the 6th rib piercing the left lung superior pole and single line left rib fracture from 4th to 8th ribs (**Figure 1**).

Base on his haemodynamic instability and paraclinical workup results, we therefore decided to perform exploratory video-assisted thoracoscopy combined with rib osteosynthesis.

2.2. Case 2

This is a 63-year-old man without a relevant past medical history who was referred to our emergency unit from a peripheral hospital. He was a passenger of a touristic car which had a turn over resulting in a chest trauma prompting his admission in a nearby hospital were progress was mark by persistence of chest pain despite treatment leading to his referral to our institution one month following the clash. On admission, he had right asynchronous chest movement, bilateral spontaneous chest pain and pain at the deltoid area. On examination, swelling of the deltoid region associated with an axe-like attitude of the right upper limb, and respiratory distress with a pulsed oxygen saturation of 90% on

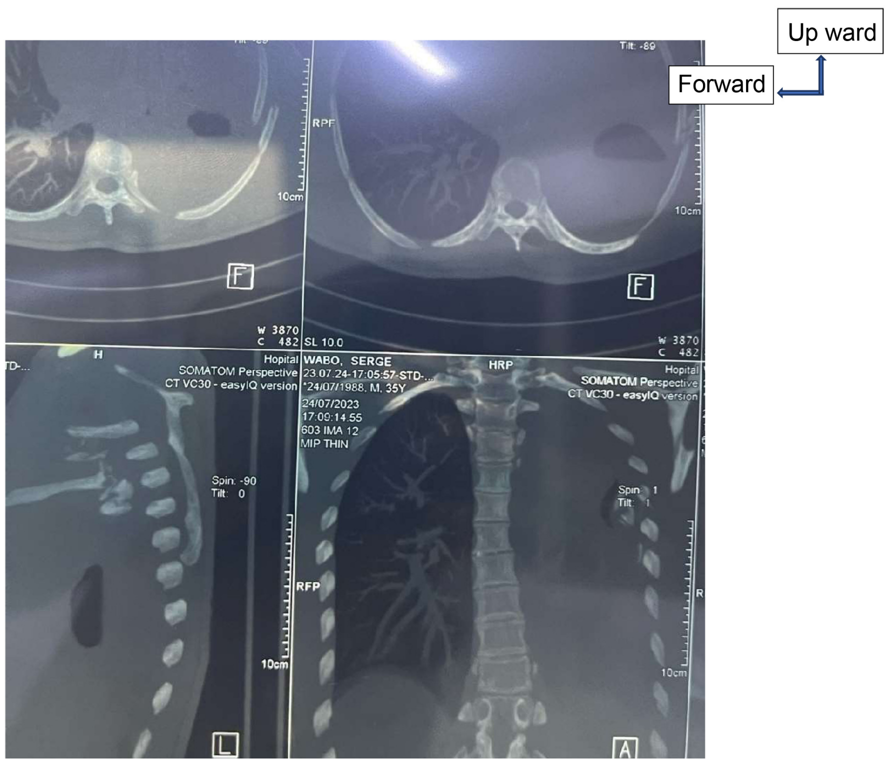


Figure 1. CT scan showing a left massive compressing haemothorax, the lateral border of the 6th rib piercing the left lung superior pole and single line left rib fracture from 4th to 7th ribs.

room air. A CT scan revealed a right lateral costal flap involving the costal borders from the 6th to 10th ribs, and isolated fractures of the middle borders from the 4th to 7th ribs (**Figure 2**). We recommended rib osteosynthesis on the right.

2.3. Surgical Technique

The surgical procedures were performed by the same surgeon, always in the first 48 hours after diagnosis. Informed consent was signed by the patients themselves (**Figure 3**). CT scan imaging of the fractured ribs often provided useful information allowing planning the surgical approach.

2.4. Anaesthesia

Operations were conducted under general anaesthesia with a double lumen endotracheal tube in order to obtain a selective pulmonary exclusion that allows exploration of the pleural cavity and lung parenchyma. The patients were positioned in a lateral thoracotomy position.

2.5. Position of the Patient and Incisions

All patients had lateral flail chest, we preferred a lateral thoracotomy, with the patient in lateral decubitus position and the arms abducted 90 degrees on a rest and carefully padded.

Intraoperatively, for the 1st patient only a single-port video-assisted thoracoscopy (VATS) at the 6th intercostal space was performed for the inspection of the thoracic cavity determining the exact localization of dislocated rib fractures and for evacuation of the existing haemothorax (1500 cc).

A curvilinear thoracic incision overlying the centre of the fractured segments using a muscle-sparing approach was done. The fractured area was previously located by the CT-scan and VATS.

Surgical incisions must be large enough to allow a good exposure of all fractured

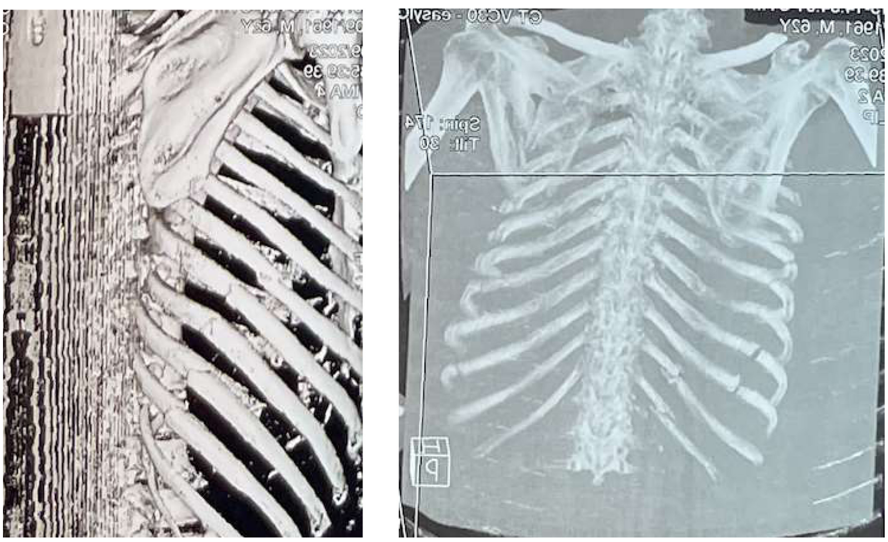
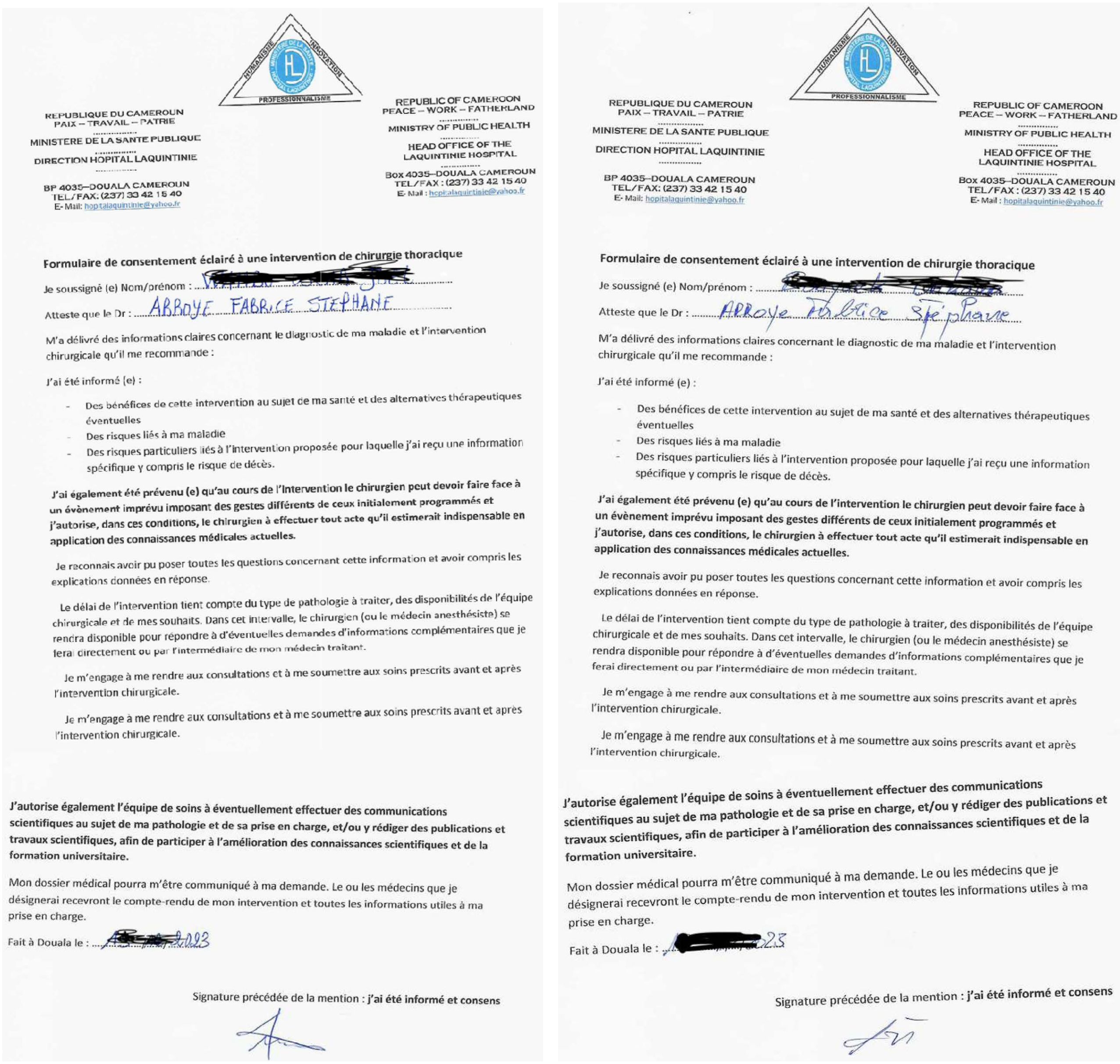


Figure 2. CT scan showing a flail chest extending from the 6th to the 10th ribs.



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Formulaire de consentement éclairé à une intervention de chirurgie thoracique

Je soussigné (e) Nom/prénom : [redacted]

Atteste que le Dr : ABBOYE FABRICE STEPHANE

M'a délivré des informations claires concernant le diagnostic de ma maladie et l'intervention chirurgicale qu'il me recommande :

J'ai été informé (e) :

- Des bénéfices de cette intervention au sujet de ma santé et des alternatives thérapeutiques éventuelles
- Des risques liés à ma maladie
- Des risques particuliers liés à l'intervention proposée pour laquelle j'ai reçu une information spécifique y compris le risque de décès.

J'ai également été prévenu (e) qu'au cours de l'intervention le chirurgien peut devoir faire face à un évènement imprévu imposant des gestes différents de ceux initialement programmés et j'autorise, dans ces conditions, le chirurgien à effectuer tout acte qu'il estimerait indispensable en application des connaissances médicales actuelles.

Je reconnais avoir pu poser toutes les questions concernant cette information et avoir compris les explications données en réponse.

Le délai de l'intervention tient compte du type de pathologie à traiter, des disponibilités de l'équipe chirurgicale et de mes souhaits. Dans cet intervalle, le chirurgien (ou le médecin anesthésiste) se rendra disponible pour répondre à d'éventuelles demandes d'informations complémentaires que je ferai directement ou par l'intermédiaire de mon médecin traitant.

Je m'engage à me rendre aux consultations et à me soumettre aux soins prescrits avant et après l'intervention chirurgicale.

Je m'engage à me rendre aux consultations et à me soumettre aux soins prescrits avant et après l'intervention chirurgicale.

J'autorise également l'équipe de soins à éventuellement effectuer des communications scientifiques au sujet de ma pathologie et de sa prise en charge, et/ou y rédiger des publications et travaux scientifiques, afin de participer à l'amélioration des connaissances scientifiques et de la formation universitaire.

Mon dossier médical pourra m'être communiqué à ma demande. Le ou les médecins que je désignerai recevront le compte-rendu de mon intervention et toutes les informations utiles à ma prise en charge.

Fait à Douala le : [redacted]2023

Signature précédée de la mention : **j'ai été informé et consens**

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Formulaire de consentement éclairé à une intervention de chirurgie thoracique

Je soussigné (e) Nom/prénom : [redacted]

Atteste que le Dr : ABBoye Fabrice Stéphane

M'a délivré des informations claires concernant le diagnostic de ma maladie et l'intervention chirurgicale qu'il me recommande :

J'ai été informé (e) :

- Des bénéfices de cette intervention au sujet de ma santé et des alternatives thérapeutiques éventuelles
- Des risques liés à ma maladie
- Des risques particuliers liés à l'intervention proposée pour laquelle j'ai reçu une information spécifique y compris le risque de décès.

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Fait à Douala le : [redacted]23

Signature précédée de la mention : **j'ai été informé et consens**

Figure 3. Informed patient consent.

ribs.

Before starting with the stabilization of the chest wall, a thoracotomy in the middle of the flail segment was performed and the pleural cavity and lung parenchyma were explored.

For the 1st patient we found a fragment of the 6th ribs piercing the left lung superior lobe pleura which extracted prior to the rib fixation (**Figure 4**).

Associated pulmonary parenchymal lesions were treated in a conservative.

A bubble test was performed to look for any parenchymal air leak.

2.6. Osteosynthesis

The primary end point of surgical stabilization of a flail chest is the resolution of

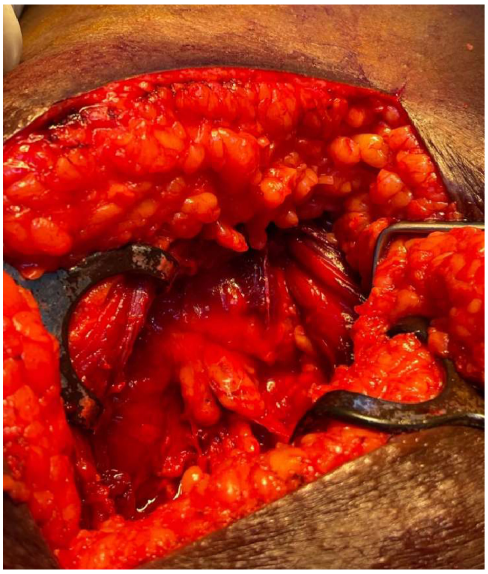


Figure 4. Fragment of the 6th ribs piercing the left lung superior lobe pleura.

the paradoxical movement of the involved chest segments.

The ribs that were to be fixed were adequately exposed in order to obtain a good placement of the metal fixation plates (**Figure 5**). When fractured ribs were exposed, the more dislocated segments were manually reduced.

We avoided excessive skeletisation of the target ribs, that can increase the risk of pseudarthrosis and significant respiratory compromise. For these reasons, intercostal muscles were dissected only in the site where a metal plate will be placed, trying to preserve as many intercostal muscles fibres as possible (**Figure 6**). Maximal care was taken to avoid stripping periosteum from the ribs.

Once both ends of a fracture line are exposed, osteosynthesis was accomplished with a 3.5 mm Judet® reconstruction plate.

When the two rib ends were adequately reduced, a plate of proper dimension was placed over the fracture line and anchored with the metallic hooks (Davier forceps) to each fracture segment (**Figure 7**).

The more angled hooks are anchored to the inferior edge of the rib. The metal hooks are grasped with suitable forceps. Angled forceps were useful to anchor plates deep in the surgical field, such as the posterior fracture line of a lateral flail chest. The length of the plates and the metal hooks must be carefully chosen to adapt to the rib size (**Figure 8**).

Once a metal plate was placed, it was reinforced with a heavy adsorbable polyfilament suture at each anchoring site.

2.7. Drain Placement and Closure

Once the reduction was considered satisfactory, a chest drain was placed in the first case using a drain connected to a PLEUREVAC-type® continuous suction device (**Figure 9**).

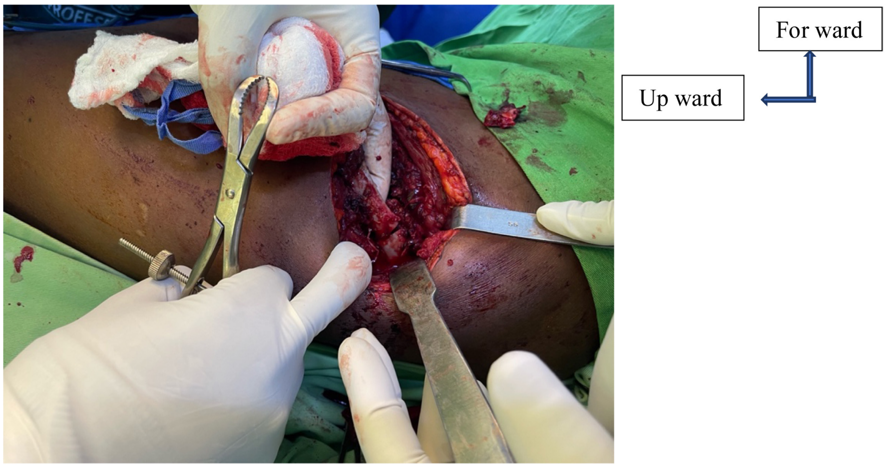


Figure 5. Lateral border of the 6th rib desincarcerated from the lung and exposed for osteosynthesis.

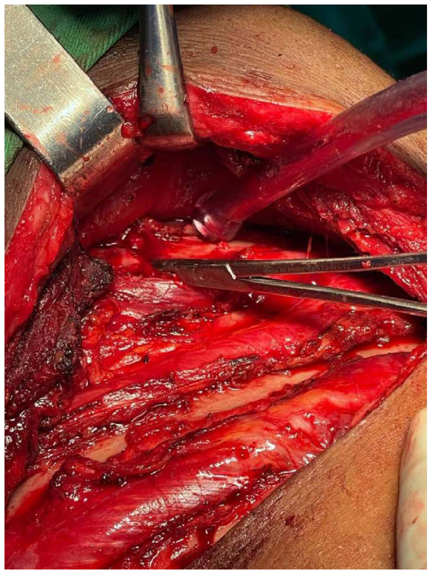


Figure 6. Exposed fracture of the 4th rib after dissection respecting the external and internal intercostal muscles.

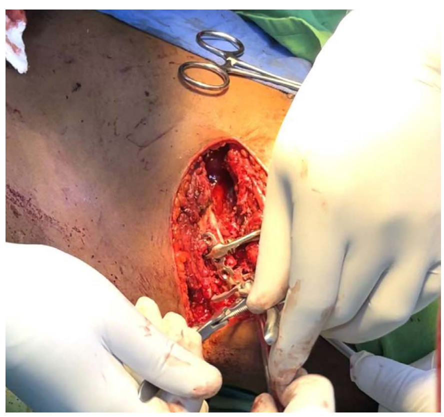
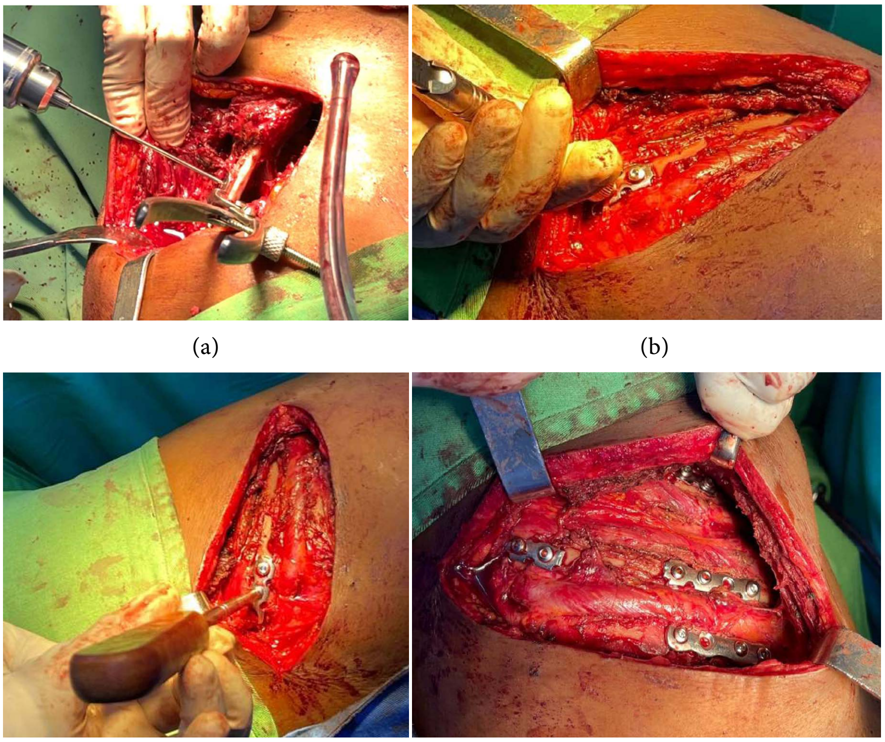


Figure 7. Judet reconstruction plate placed on either side of the fractured rib using Davier's forceps.



(a) (b)

(c) (d)

Figure 8. Different steps of rib osteosynthesis with Judet. reconstruction plate (a) Drilling of the rib; (b) Placement of a deep jauge (calliper) to obtain the measurements of the screw; (c) Screwing to fix the plate; (d) The Repaired chest wall.

Figure 9. Continuous suction device.

Prior to thoracotomy closure, ropivacaine 2 ml/ml, diluted in saline, was infiltrated into the intercostal spaces to prevent post-operative pain.

When closing the interspace of the thoracotomy, particular care must be taken not to displace the metal plates on the fixed rib on either side of the interspace.

The surgeon and the assistant should pull the sutures tight at the same time to avoid rib dislocation. Once the chest wall was closed, the muscles and skin were sutured in the usual manner.

Extubating was performed on the operating table, and the patients were sent to the intensive care unit for 12 hours monitoring, then to transfer to the hospital ward.

2.8. Postoperative Course

A postoperative chest x-ray was obtained, on the first post-operative day, and a CT scan was performed on the second post-operative, revealing good pulmonary re-expansion in the first case, and reduced rib fractures, with a small residual pleural effusion on the right in the second case (**Figure 10(a)**). The drain was removed on the third postoperative day in both cases.

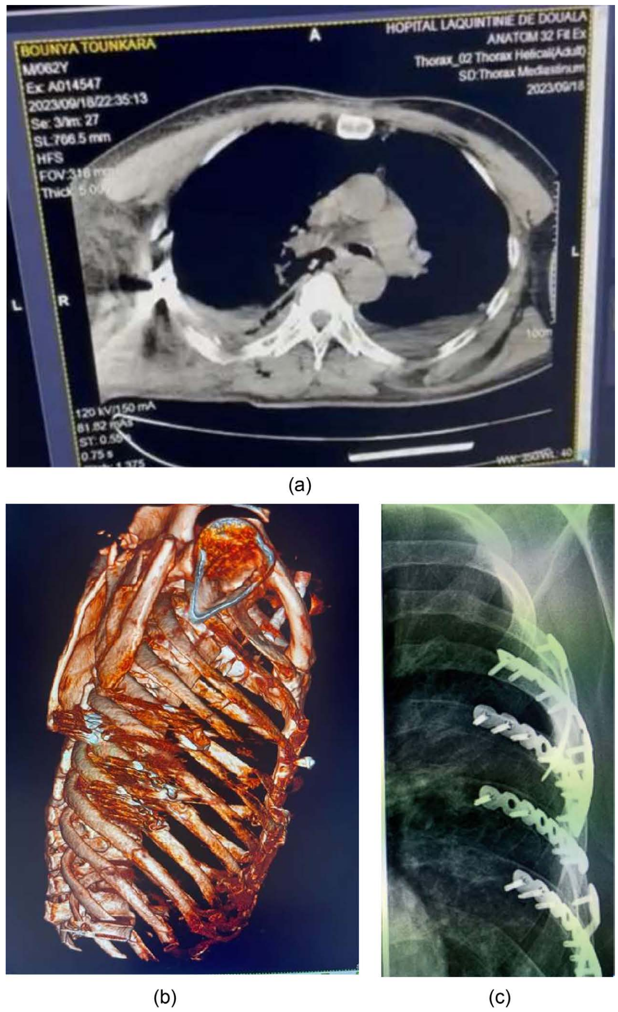


Figure 10. Post-operative follow-up imaging. (a) Axial sections of thoracic CT scan revealing minimal pleurisy opposite the synthesized rib; (b) Thoracic CT scan revealing artefacts opposite the reduced rib; (c) Judet plates reconstruction reducing rib bills from K4 to K8.

Given the good clinical and biological evolution, with no chest pain and a pulsed oxygen saturation of around 99% on room air in both cases, the patients were discharged on 8^{th} and 11^{th} postoperative days respectively in case 2 and case 1. Follow-up radiographs taken one month after surgery were unremarkable, as they correlated with those taken during the early post-operative period (**Figure 10(b)** and **Figure 10(c)**).

3. Discussion

Generally, not every preoperatively proven fracture needs to be treated osteosynthetically, so the treatment depends on the severity of the chest wall injury, the condition of the underlying lungs, the degree of hypoxia which is determined by arterial blood gases, the age of the patient, the presence of pre-existing lung disease, and the pain threshold of the patient.

Consequently, several surgical and non-surgical strategies have been applied in the treatment of rib fractures or flail chest over the years with the aim directed towards maintaining adequate ventilation, decreasing progressive damage, and preventing complications and sequelae [5]. Surgical solutions must be tailored to the individual case. Early surgical techniques have not shown superiority compared to conservative treatment and mechanical ventilation. Perhaps, the indications for rib plating are not well established, and researchers are ongoing to clearly define all rib fixation indications. Existing guidelines recommend that patient that should be consider are those with 3 or more acutely displaced fractures, those with flail segments, those that fail optimal non-operative management, and patients with rib fractures that require thoracic surgery for other indications [6].

The diagnosis of our patients was made base on their history of chest trauma, physical evaluation and paraclinical investigation findings. On the same line, the first patient presented a secondary deterioration of his case following initial conservative management with persistence of his symptoms up to 64 days after his accident while for the second patient we noted a persistence of pain regardless of analgesic and flail chest paradoxical chest movement up to 30 days after trauma. They both had criteria for an operative rib fixation which is beneficial for pain relief, length of stay in the ICU, length of mechanical ventilation, and decreasing incidence of pneumonia. This led us to readjust their therapeutic plans and swift toward surgical therapy due to a probable secondary displacement of the rib fracture during hospitalization, injury to the adjacent intercostal pedicle, justifying the absence of initial symptoms for the first case while for the second case the delay could be attributed to his initial management in a peripheral centre where they failed to recognise his symptomatology as a surgical emergency to refer him earlier to our institution.

One unknown factor under current study is the appropriate timing of fixation. Moreover, the majority of studies evaluating the effectiveness of surgical rib fracture fixation have been performed in the acute setting and, in particular, in patients with flail chest. Several authors propose early surgery rather than later aiming at mitigating pain and avoiding or resolving the need for mechanical ventilation, shorter ICU and hospital lengths of stay [7] [8]. In addition, when surgery is offer within 48 to 72 hours after the trauma, infection and pulmonary complication resulting from alveolar hypoventilation can be prevented [9]. Also, the time of surgery has not been formally established, due to the evolution of the pulmonary contusion, and recent studies agree that osteosynthesis should be proposed within the first 4 to 6 days following the trauma, as the reorganization of the wall makes reduction difficult beyond this time, while increasing the risk of infection [10] [11]. In contrast, a prospective randomized study, showed that patient operated one month or later had a more improved percentage of forced vital capacity and they also found a reduction in medical costs [12]. Also, Bhatnagar *et al.* theory on whether open reduction and internal rib fixation for the flail chest was a cost-effective way to manage these patients was confirm by their findings revealing a significant clinical improvement, surgical fixation also remained the most cost-effective strategy, with cost savings of $8400 per patient on average [13]. Concerning our cases, we endeavour to carry out our surgery within 72 hours following our diagnosis and decision to carryout surgical rib fixation, but our practice was adapted to our context in a low middle income country where there is no social insurance and the patient are the sole financial provider to cover all the expenses. This may explain the attempts to start initially with a conservative attitude in the first case or delay referral in the second.

However, the advantages of surgical stabilization remain valid only if the surgeon carefully selects patients for rib fixation: they benefit from surgery if a trial of mechanical ventilation has failed, if patients have severe chest wall deformities with multiple rib fractures or flail chest and severe displacement or uncontrolled persistent pain, or if they need thoracostomy for other indications. Therefore, surgery was considered in the first case because of evidence of potentially life-threatening lesions, such as pulmonary injury or poorly controlled haemothorax associated with rib fractures while for the second case indications were his advanced age, persistence of pain, chest deformity and asynchronous chest movement. In addition, their CT scan images also supported the indication of a surgical repair.

Our second patient was aged 63-year-old, literature report an increased risk of unfavourable outcome with age following a closed chest trauma [14] [15]. On the same line, Kent *et al.* found out that rib fractures are responsible for 56% of mortality in patients aged 65 and over with thoracic trauma [16]. Given poor result and the rise of pneumonia as the main complication associated with the management of flail chests using mechanical ventilatory called internal pneumatic stabilization by Avery *et al.*, new principles of flail chest management such as adequate analgesia and aggressive pulmonary physiotherapy have been put in place [17]. On the same line, several studies concerning the controversy surrounding the surgical indication of unstable chest walls have been reported, some results show that surgical fixation of flail chests is associated with lower hospital as a consequence of faster weaning from mechanical ventilatory support, shorter ICU (intensive care unit) stays, and faster recovery of lung function [18]. Additionally, rib osteosynthesis has also been proposed as part of the management of so-called old or aged trauma, characterized by paradoxical breathing with the impossibility of ventilatory weaning.

Several randomized controlled trials have been published over the last decagon comparing surgical approaches in the management of flail chest with conservative treatment. All of them demonstrated significant improvement after surgical stabilization with regards to the length of mechanical ventilation und ICU stay, decreasing rate of pneumonia as well as a significant improvement in long-term outcome such as chest pain, chest tightness, dyspnoea, time to return to work and ability to high-activity work was reported in several studies [19]. In contrast, Farquhar *et al.* reported in his retrospective series no benefit of surgical rib fixation vs. conservative treatment regarding time of mechanical ventilation, length of hospital stays and pneumonia onset, while reading his result we should consider the study limitations. There was a small number of patients, especially in the surgical group which was made of those operated after ineffective conservative management. May be an earlier surgical approach might lead to a better outcome in the surgical group [20].

Concerning the patient position and surgical incision it all depend on the fracture localisation. Rib fractures are mainly located in the in the mid- to posterior axillary line, thereby requiring the patient to be placed in a lateral decubitus position. For anterior fractures (anterior to the anterior axillary line), patients can be positioned supine. While, posterior fracture (posterior to the posterior axillary line) can be approached with the patient in the prone or lateral decubitus positions. We placed our patients in lateral decubitus, since their fractures involved the lateral portion of the rib.

The role of VATS in management of chest trauma has been described in the literature. Although a very sparse amount of randomized prospective data for the role of VATS in operative management of chest trauma patients exists, VATS can be beneficial in non-critical, haemodynamic stable patients. So, VATS can be a useful explorative and therapeutic procedure to aid localization of fractures, evacuate retained haemothorax, and perform repair of some associated injuries like we did in the first case. (eg, diaphragm rupture) [21]. Then, thoracoscopic evaluation of the thoracic cavity can identify misdiagnosed lesions and avoid delayed complications.

One of our main intraoperative fears was pseudoarthrosis of the rib due to surgical management delay, fortunately there was lack of consolidation of the fracture, so in neither case we could found it. So, we should not limit ourselves with surgery timing in posttraumatic rib fracture but consider proceeding to surgical management as far as there is an indication despite inflammatory or infectious risk. Furthermore, the surgical indication remained relevant and the results satisfactory.

All dissection and manipulation of the rib should occur from the anterior and superior aspects to avoid injury to the neurovascular bundle, which is located inferior and slightly posterior to each rib. Rib fixation plates are contoured for the curvature of the rib. According to literature, there are several techniques for ribs fixation [5]. Besides, there is a number of implants that have been specifically designed for ribs fractures fixation These include locking plates (MatrixRIB, Synthes, West Chester, Pennsylvania), splints (MatrixRIB, Synthes), U plates (Ribloc, Acute Innovations, Hillsboro, Oregon), Judet struts and a mesh wrap (Inion Orthopedic Trauma Plating System, Inion Oy) [22]. Therefore, when selecting a surgical device for rib fixation, the surgeon should consider the ease of the operation, the biochemical properties of the device, the risk of complications, and the implant's cost, as well as the hospital's resources availability [23]. All but one of the commercially available rib plating systems require open operative repair; however, the plating systems used today have a smaller profile and less need for dissection compared with those used in the past [24]. Plating and screws such as the MatrixRIB™ (DePuy Synthes™) system are very accurate and provide excellent stabilisation. We can manipulate plate by length and curved to allow for precise contouring. They are however expensive and increase the operative time due to the need for additional contouring. The use of Kirschner wires is easy and cheap, but it does not offer guaranteed stabilization and there is a risk of migration. About sixty percent of those who are stabilised with wires did not maintain rib fracture stabilisation and thus do not reap the full benefits of rib fixation [1]. The Judet strut is a bendable metal plate that grasps the rib with tongs both superiorly and inferiorly without transfixing screws, also this fixation technique is simple, less invasive, convenient, shorter, and can be applied without any pleural injury. However, there is a risk of crimping the intercostal neurovascular bundle with intercostal nerve injury and chronic pain [25]. Furthermore, some plating systems require drilling holes into the rib prior to insertion of screws, whereas others use self-tapping screws, thereby saving a step. All systems (except Level One; anterior fixation using 1.5-mm screw) require the surgeon to measure the thickness of the rib to determine the proper screw length. This is done using a calliper that is unique to each rib plating system. Regardless of the type of plating system that is used, it is vital that plates are secured to healthy bone at least 2 to 3 cm away from the fracture line. Our case highlights the use of 3.5 mm Judet strut to stabilise the fracture rib fragments in our context. Although the published literature on surgical fixation has grown rapidly, this technique remains unfamiliar to most surgeons. However, it is believed that surgical fixation of the flail chest will become the standard of care in the future, as barriers to this underused surgical procedure are overcome [26].

Documenting our cases enable us to obtain preliminary results in a low-middle income country which could therefore be considered encouraging. More cases such as this are needed to determine further the short- and long-term outcomes of surgical rib fixation in limited-resources so that management guidelines can be developed. It should also encourage encourage the popularisation of this surgical approach and technique, for a pathology induces significant mortality and morbidity, even in our context.

4. Conclusion

Surgical stabilisation of rib fractures reported in this case report highlight a promising surgical technique that deserves to be more widely used in the management of the complex condition of rib fracture and flail chest in a low-resource country, regardless of how long it takes to receive treatment. However, there is a need for larger randomized, and controlled trials to clarify the benefits of this technique. Indeed, there is a need of studies comparing different surgical approaches although such studies will be difficult to conduct due to a low number of surgical cases.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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