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Traumatic posterior sternoclavicular joint dislocation – Current aspects of management

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ABSTRACT

The posterior sternoclavicular joint dislocation is a rare and potentially life-threatening injury, as massive haemorrhage can occur at the time of trauma, during reduction manoeuvres and drilling. These injuries are rare and a collective experience of managing them is of paramount importance. We present our multidisciplinary experience of managing several of these injuries in our centre, with learning points we have identified.

Assessment should include Computerised Tomography Angiography (CTA) to assess the anatomy of the joint including the proximity to the underlying innominate vein and to identify any bleeding. Both closed reduction and open reconstruction have the potential for massive haemorrhage which can be controlled successfully with direct access to the underlying vessel. We recommend that all reductions should be performed in the presence of a cardiothoracic surgeon who can gain vascular control in the head, neck, and thorax. In specific high-risk cases, pre-emptive venous catheterisation can also be considered. We recommend that a discussion and rehearsal for intra-operative bleeding should be undertaken with the whole theatre team, with roles assigned pre-emptively and to allow identification of any deficiencies in staff expertise or equipment.

Of the five recent cases managed in our centre one patient had a closed reduction and four had open reductions. Success of closed reductions within 48 h is high and these can be attempted up to 10 days after injury. Our patient undergoing closed reduction had a favourable outcome and returned to professional rugby at five months. Open reduction was performed in a physeal fracture as there was a delay to surgery and callus had begun to form and had the potential to adhere to the underlying vessel. In this case we performed open reduction and stabilised with tunnelled suture fixation. Our preferred method of reconstruction uses a palmaris graft with internal figure of eight bracing. One patient had a subsequent fracture of the medial clavicle around the drill holes that healed without further intervention. Despite good reduction and stability achieved following palmaris reconstructions, two patients are experiencing ongoing symptoms of globus and one with voice change without any objective underlying cause.

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Introduction

Traumatic posterior sternoclavicular joint (SCJ) dislocation is a relatively uncommon injury – few orthopaedic surgeons have experienced more than an occasional case – but has the potential to be life-threatening due the proximity of major intrathoracic vasculature. The literature provides only small case series on a variety of treatment options from which it is difficult to formulate a treatment algorithm. Few details are available on the recommended precautions which should be taken to prevent iatrogenic injury during reduction.

We detail a series of posterior sternoclavicular joint dislocations referred to our facility which were treated with input from a multidisciplinary team (including interventional radiology and cardiothoracic surgery) and present a review of the current literature and the recommendations for perioperative precautions formulated from this multidisciplinary experience.

Pre-operative assessment

Traumatic posterior sternoclavicular joint dislocation occurs from either direct or indirect blunt force to the shoulder [1]. A compressive

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lateral impact to the shoulder may drive the clavicle medially and posteriorly behind the manubrium or a direct anterior blow to the medial clavicle may translate it posteriorly. These are generally higher energy injuries but may also occur from simple falls or impact sport [2–5]. Other severe injuries may need to be treated concurrently and it is common for the SCJ dislocation to be missed in the presence of distracting injuries [6,7].

The medial clavicle physis does not close until around 25 years of age [8]. A high index of suspicion and lower threshold to undertake computed tomography (CT) imaging [9] should be maintained in this age group as it is common for physeal injuries to be missed initially [10].

Specific symptoms such as shortness of breath, globus, swallowing difficulties or voice change should be documented. On examination, the shoulder may appear protracted, and the patient may prefer to sit up, holding the arm adducted and supported with the head tilted to the injured side [11]. Documentation should include the presence or absence of distal pulses, brachial plexus examination and any evidence of venous congestion in the arm or neck. It is important to examine the acromioclavicular joint (ACJ) and lateral clavicle, injuries to which may result in a floating clavicle.

Case learning point 1

26-year-old farmer sustaining fall from quad bike with lateral compression force. Presented with pain and deformity over ACJ and SCJ with hoarse voice and swallowing difficulties. CT scan showed a Grade III ACJ injury with posterior dislocation of the SCJ. 3D reconstruction of both clavicles and ACJ joints demonstrate a significant inferior posterior rotational displacement of the clavicle along its longitudinal axis. The inferior border of the medial clavicle is concave with a medial inferior prominence. Rotation of this prominence 90 ° posteriorly can mimic a posterior dislocation as the bone protrudes posteriorly into the mediastinum. In this case a standard hook plating of the ACJ restored the rotational deformity of the SCJ back to a stable anatomical position. Fig. 1

Imaging

The injury may be suspected in a routine trauma chest radiograph however, a specific “Serendipity” view can be performed, centred on the sternum with a 40 ° cephalad tilt of the beam towards the supine patient [12]. This view is useful to assess and compare a subsequent reduction intra-operatively. Ultrasound can also be used for diagnosis and assessment of the proximity to the underlying vascular structures but is limited by operator experience and the ability to obtain an appropriate acoustic window [6,13].

The gold standard imaging is contrast-enhanced computerised tomography (CECT) to visualise the vascular structures. Reconstructed CECT images including both clavicles and acromioclavicular joints allow assessment of subtle rotation, translation and shortening displacement. Axial images give the best visualisation of the posterior displacement and proximity to the underlying great vessels. Fig. 2

MRI can be useful in the setting of physeal fracture and in the assessment of chronic dislocation to assess integrity of the ligaments [14].

Pre-operative planning

After clinical and radiological assessment, treatment planning should include an assessment of the expertise and facilities required to perform reduction safely and in a timely manner to maximise success. Whilst many upper limb surgeons will have the knowledge and technical expertise to manage these safely, because of the potential for serious vascular injury, it may be prudent centralise the care of these injuries. Technical aspects of the pre-operative planning should include timing of reduction, closed or open reduction, reconstruction and repair options and mitigation of any potential bleeding risk.

Timing of reduction

In the stable patient without mediastinal injury, the optimal time for the reduction to be performed is dictated by the availability of appropriate personnel and equipment to manage all eventualities. Therefore, we suggest a centre undertaking such procedures should have cardiothoracic support, blood transfusion services, interventional radiology, intensive care and an experienced orthopaedic surgeon. Although closed reduction is most successful before 48 – 72 h [15,16], it would usually be advisable to delay reduction for a short time until the appropriate resources are available.

Case learning point 2

A 15-year-old presented three weeks after injury with a posteriorly displaced physeal fracture without clinical or neurovascular compromise. A date for open reduction was delayed a further 16 days to allow allocated cardiothoracic theatre time with a cardiothoracic surgeon and second orthopaedic consultant. Callus had to be resected to allow reduction. Reduction was held with multiple tape sutures in a figure of eight configuration through medial clavicle, epiphysis and manubrium. It was felt the delay to theatre was acceptable despite the increased risk of callus development.

In the presence of mediastinal or airway compression the decision pathway will vary depending on the available services, expertise and time to transfer. Consideration should be made weighing up the risks of undertaking closed reduction without cardiothoracic and interventional radiology, versus the risk of life and limb if a significant delay to reduction occurs. Discussion with the nearest Level 1 Trauma Centre should be undertaken and a decision reached considering any likely ischemic time, the severity of compressive symptoms, time to transfer and risk of catastrophic haemorrhage. Massive bleeding necessitating thoracotomy has occurred on reduction of posterior dislocations as the tamponade effect on the great vessels is released [17].

Closed reduction

Success of closed reduction in adults is between 38% [16,18] and 50% [15] when undertaken in the first 48 h. Unless there is mediastinal injury a closed reduction can be attempted and there are cases of late presentation (10 days) in adults being reduced successfully without complication or recurrence [18].

Laffosse et al. have reported the largest series of 30 patients and all attempts at a closed reduction of a physeal slip were unsuccessful (n = 4) [15]. However meta-analysis of 90 physeal injuries with attempted closed reduction in patients 12–18 years old was completed by Tepolt et al. describing a 55.8% success rate in the first 48 h and 30.8% thereafter up to 10 days. No significant complications occurred following attempted closed reduction and the authors conclude that this can be attempted safely for up to 10 days post injury if no other mediastinal injury is present.

Case learning point 3

Professional rugby player aged 21-years-old carrying the ball, sustained a posterior dislocation with no mediastinal injury after collision to his left side. Closed reduction was performed within 48 h of injury in theatre with cardiothoracic surgical team pre-

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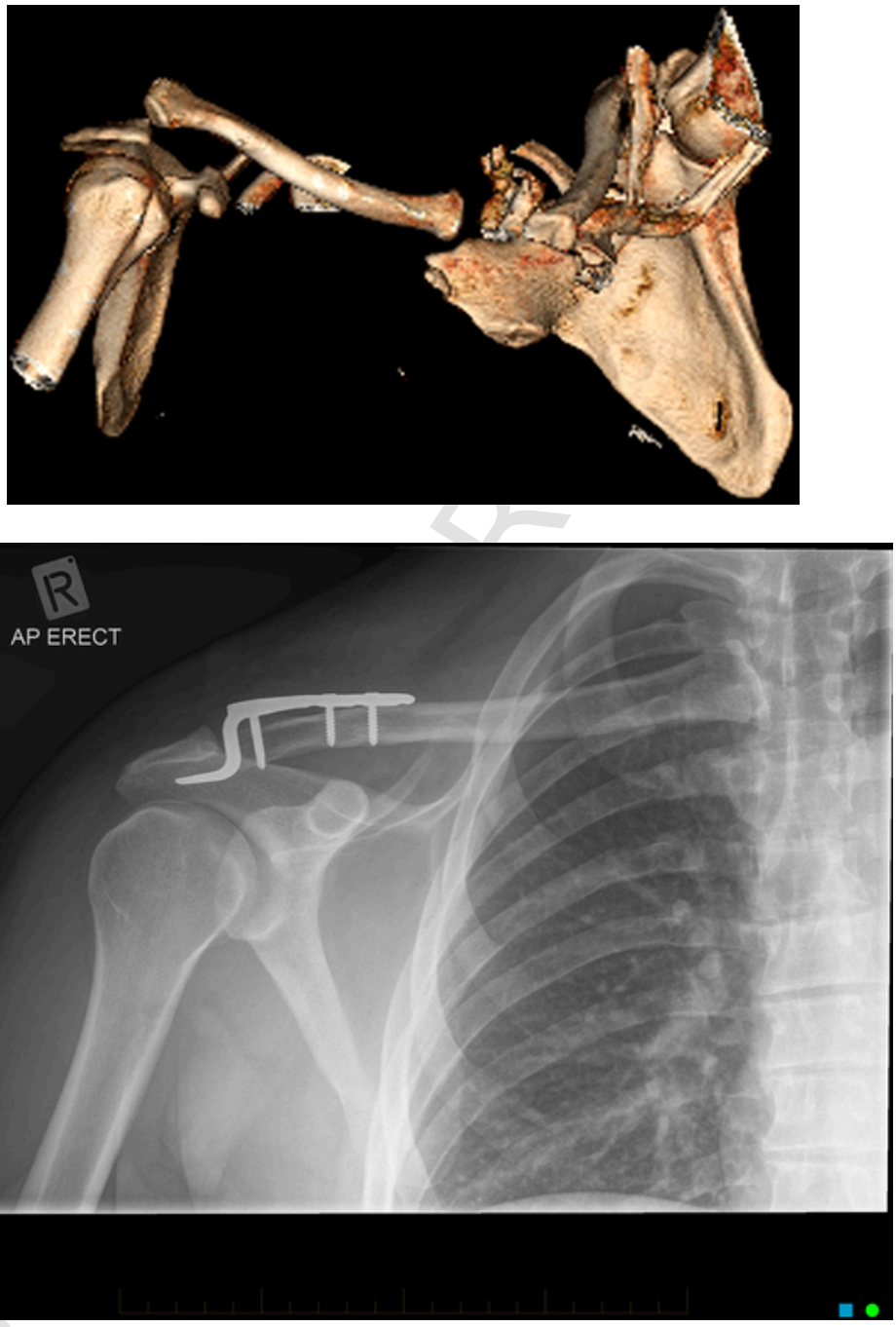

Fig. 1. a Posterior rotation of the clavicle along its longitudinal axis with the appearance of a posterior SCJ dislocation and Grade III ACJ injury 1b Hook plate fixation restored stabilisation at the SCJ.

sent. Reduction was achieved with radiolucent sandbag placed between the scapulae, and with gentle traction of the arm and manual manipulation of the clavicle reduction was easily achieved. He was placed in a figure of 8 brace and remained stable

Two other closed methods are described:

1) A towel clip method to pull the medial clavicle anteriorly is described by Carius et al. [19]. The towel clip pierces the skin and encircles the medial clavicle and is in close proximity to the vessels.
2) An entirely anterior approach to avoid inadvertent disruption of the underlying vessels is described by Hadi and Limb [20]. A percutaneous 50 mm small fragment screw is placed through a 5-hole plate and the anterior cortex of the medial clavicle. The plate is used as a T-handle to allow the clavicle to be pulled forward.

Stabilisation or reconstruction

Indications for open reduction and stabilisation include failed closed reduction, mediastinal compression or injury and late presentation

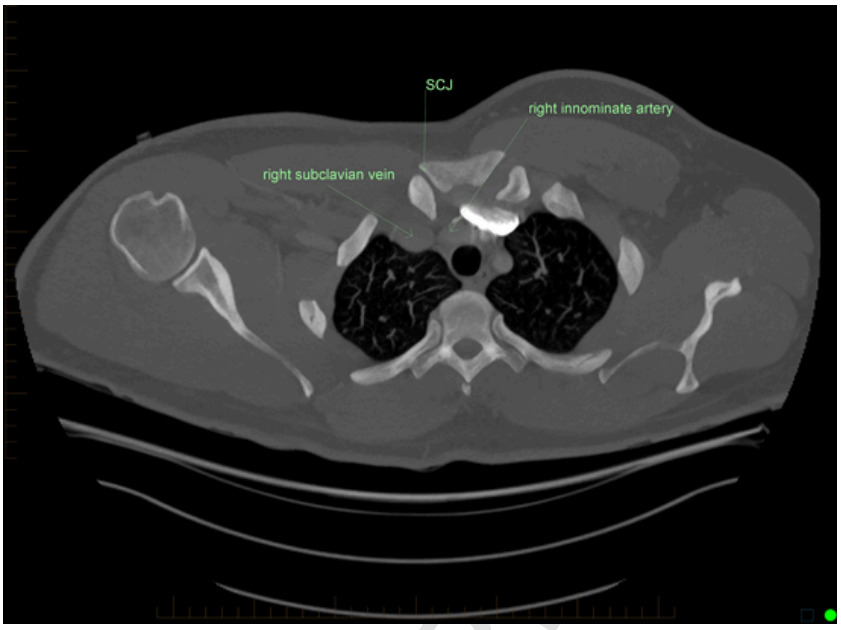

Fig. 2. CT angiography showing proximity of subclavian vein and innominate artery to the sternoclavicular joint.

greater than 10 days, where callus could be adherent to underlying vessels [1]. Considerations in choosing the method of stabilisation technique include the expertise of the surgeon, availability of equipment, degree of instability, the patient's future sporting goals, secondary procedures to remove hardware and time to reduction.

In the chronic setting, open reduction and reconstruction of the ligaments should be the method of choice but either reconstruction or repair techniques can achieve stability in the acute setting.

Joint capsule and sternoclavicular ligaments are the first structures to be disrupted in a Type II injury described by Allman [21]. Stability of the joint is often maintained if the costoclavicular ligament remains intact. When the costoclavicular ligament is ruptured in a Type III injury then significant instability occurs [1].

Direct repair of the ligaments is generally not achievable and therefore supplementation with either suture or tendon is required to stabilise the joint. The most important joint stabilisers are the joint capsule and sternoclavicular ligaments. In an anatomical study selective division of the joint capsule caused displacement of the clavicle, however selective individual cutting of costoclavicular, intraarticular disc or interclavicular ligament did not affect stability. The type of reconstructive stabilisation should re-create the restraint of the capsule and ligaments that are deficient.

Tunnelled fixation either uni-cortical [22] or bi-cortical [23], cerclage sutures [24] or suture anchors [25,26] that re-enforce the anterior sternoclavicular ligament and joint capsule repair are the least technically challenging and a relatively safe repair in the acute setting.

Tenodesis options are subclavius to restore the costoclavicular ligament [27,28] and sternocleidomastoid to reconstruct the sternoclavicular ligament [29]. Both approaches are used in the case series by Laffosse et al. and although k-wire and cerclage wire were used as supplementary fixation the authors advise that on review these should not be used due to the concern of wire migration, which can be fatal [15,30].

Use of hook [31,32] and Balser plates (Peter Brehm Chirurgie-Mechanik, Weisendorf, Germany) [33,34] that hook under the manubrium are a stabilisation technique that favours anterior dislocations, as this acts as an anterior restraint. Anterior buttress plating [35,36] with fixation on the clavicular side only, and uni-cortical transarticular plating [37] have also been successful in reducing posterior dislocation. Although locking plate fixation was used, we must also assume bi-cortical fixation is needed to hold the reduction under the loads required in buttress plating and therefore there must be some protrusion of the screw threads on the posterior aspect of the clavicle with the theoretical risk of vascular injury. With all plating techniques a secondary procedure to remove the implant is required.

Reconstructive options include the use of biological (auto or allograft) or synthetic grafts. Biological grafting techniques include palmaris, plantaris [29] or hamstring autografts[38,39] and hamstring allografts [40,41]. Synthetic grafts described include the use of sternal cables [42] and Polyester tapes 10 mm Rota-Lok™ (Neoligaments, Leeds, England) [43].

Case learning point 4

Palmaris autografts were used in two cases to reconstruct the sternoclavicular ligaments. In one case a uni-cortical figure of 8 technique supplemented with a bi-cortical Fibertape® (Arthrex, Inc. LA0239. Naples, FL; 2008) internal brace, Fig. 3. A subperiosteal dissection on the sternum and clavicle allowed a curved blunt Homan retractor to be passed safely behind the SCJ protecting the drill from plunging. The length and width of the palmaris graft was found to be satisfactory in both cases. The average length was 16 cm allowing it to be passed through both the clavicle and sternum uni-cortically and be re-sutured back onto itself, Fig. 3b. We found the tendon and Fibertape® was easily passable through 3.5 mm drill holes that were placed in the medial clavicle and manubrium, Fig. 3c. We recommend tying the Fibertape® suture first to maintain the reduction and the tendon graft second.

Consent

Patients should be appropriately consented prior to surgery, including for any supplementary procedures e.g., interventional and cardiothoracic interventions. Discussion points should include:

1 Planned surgical approach – including closed and open reduction and in the case of reconstructions the possible harvest of autograft and the morbidity associated with graft harvest [44] (68%) or the use of allograft and its relative risks.

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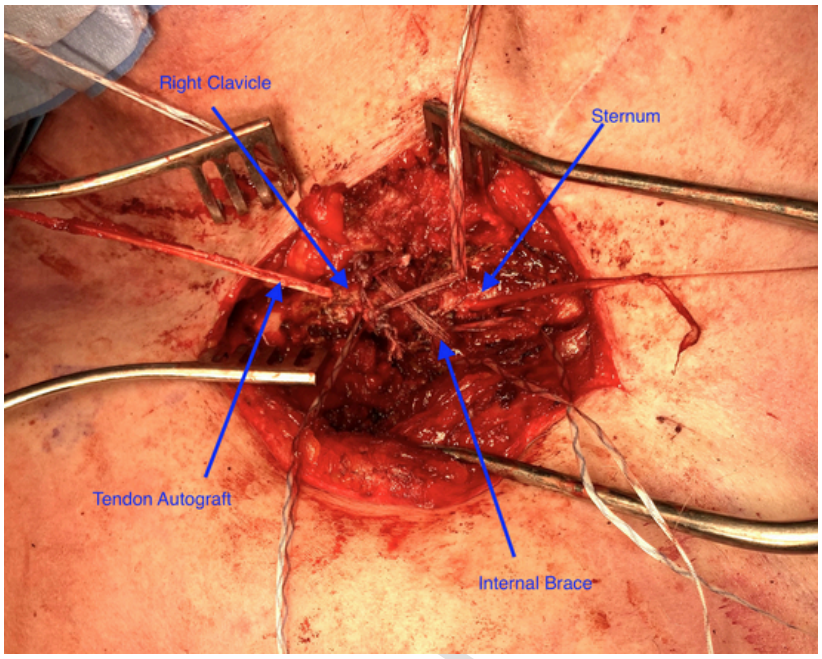

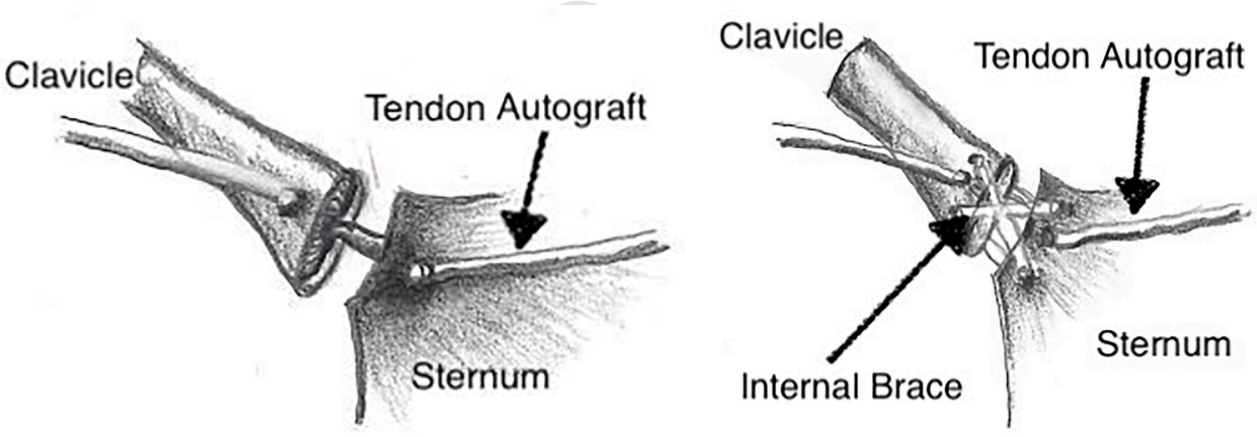

Fig. 3. a) Reconstruction with uni-cortical palmaris graft and bicortical figure of 8 internal brace, b) unicortical drill holes through clavicle and sternum and palmaris graft and c) including bicortical drill holes and figure 8 internal brace.

2 Immediate and life-threatening complications including great vessel, oesophageal, trachea and brachial plexus injury, massive bleeding and embolism all which can result in death. All are extremely rare in the circumstances where an injury has not been identified on CT scan pre-operatively with no cases have been reported directly in the literature [16]. Blood transfusion requirement and its relative risks should be discussed.
3 Common surgical complications, infection, ongoing instability (14.3%) [45], persistent dysphagia, voice change, dysphonia, fracture [46], osteoarthritis [45] (21%), swelling and asymmetry.
4 Further procedures – including planned removal of any implants.

Pre-operative surgical briefing

As is internationally accepted Safe Surgery practice, the surgical briefing should be attended by the entire team. Multiple teams may be involved in these procedures, and some may be working outside of their usual environment. Effective teamworking and a shared mental model enable safer surgery and a more effective approach. Anticipated complications should have an advanced plan that can be activated should the need arise.

Personnel

The suggested theatre team composition is detailed in Table 1.

Equipment

The decision to perform this in hybrid operating room, cardiothoracic theatres, trauma theatres or the interventional radiology suite will be a discussion between specialities and the appropriate location will vary between centres.

Table 1
Suggested specialists involved in the operative management of posterior dislocations of the sternoclavicular joint.

Specialist	Skills needed
Orthopaedic Surgeon	Undertake both open and closed reduction and perform stabilisation of the SCJ. In our experience double consultant fellowship-trained shoulder surgeons have been present in theatre for open reductions. Closed reduction can be attempted if no mediastinal injury is evident preoperatively by a generalist orthopaedic surgeon in the presence of cardiothoracic support.
Cardiothoracic Surgeon	A surgeon should be present in theatre who is familiar with gaining vascular control in the chest and neck and can perform vessel repair, grafting and shunting.
Interventional Radiology	An interventional radiologist who can gain vascular access, place a balloon to assist with temporary haemostasis and perform arterial or venous stenting if appropriate.
Radiographer	A radiographer for confirmation of endovascular balloon or device placement, reduction on fluoroscopy.
Scrub team	The scrub team should have expertise in orthopaedic and cardiothoracic surgery.
Anaesthetics	The need of a specialist cardiothoracic anaesthetist and clinical perfusionist will need to be assessed on a case by case with the likelihood of needing this expertise being extremely rare and usually pre-planned in the presence of known vascular injury.
Other	If other injuries or symptoms present an ENT surgeon may also be required. Intensive care team should be aware of possible admission.

Case learning point 5

In our experience it is easier to move orthopaedic equipment to cardiothoracic or hybrid theatres then vice versa. Open reduction performed in a Hybrid Operating Theatre enables rapid endovascular haemorrhage control prior to thoracotomy

The equipment and expertise to perform a thoracotomy must be available. The ability to give high volume warmed massive transfusions either with a Level one rapid transfuser or similar and to go on to cardiopulmonary bypass as required must be available. Depending on the surgical plan suture anchors, synthetic tapes, autograft, allograft or synthetic graft need to be available. Allograft often requires pre-ordering and preparation or thawing prior to use.

Bloods products

The blood bank should be informed of a potential for massive haemorrhage and appropriate massive transfusion packs prepared. As in any massive transfusion situation, it is important that the team anticipate the potential for this to be required, are aware of their roles and how this process works in their centre.

Positioning and prepping of the patient

Position and preparation of the patient and approach must allow the surgeon to reduce and stabilise the SCJ safely. Beach chair position has its advantages as it controls the head position and allows good access for the image intensifier. Downsides include the reduction in cerebral perfusion and potentially reduced access for the interventional radiologist [47]. Using the head support from the beach chair table and only a slight upward tilt of the torso may represent a reasonable compromise. Position must not hinder the ability to perform thoracotomy or gain vascular control in the neck. The use of a thoracotomy drape allows access to chest, SCJ and neck. Access to the groins or arms for endovascular control should be decided with interventional radiology prior to positioning and draping. If host tendon graft is to be taken this may compromise access to one limb and should be factored in when deciding vascular access for interventional radiology and anaesthetics. Regional cerebral oxygen saturation monitoring should be considered when patients head is positioned higher than the heart and can be used if there is cross clamping of the brachiocephalic artery to monitor retrograde flow to the brain [47].

Practice or rehearse for bleeding

In the pre-op briefing a plan should be discussed and rehearsed for the encounter of massive haemorrhage. This has several advantages 1) it will identify if you are deficient in either equipment or personnel, 2) allow task focussed roles to be assigned so people work reflexively and 3) instil confidence in the team. The first steps when bleeding is encountered are detailed in Table 2.

The most common bleeding points are the innominate vein and artery [48]. On average a great vessel is 6.6 mm behind the clavicle and 12.5 mm behind the sternum at the level of the SCJ [48]. All drill holes in a figure of 8 reconstruction were at high risk of vascular injury in a CT simulated experiment [48].

High risk manoeuvres include reduction as this can avulse the vein, and drilling, a cardiothoracic surgeon should be present at this point in the surgery. Exsanguination can occur rapidly, and prompt proximal and distal control of the bleeding must occur.

Pre-emptive endovascular assessment via catheter angiography can allow placement of balloon catheters in anticipation of bleeding to mitigate both exsanguination and air embolism while direct control is achieved. We suggest only deployment of these in cases in which there is specific high risk of vein injury such as close proximity, potential for callus adherence to the vein or known innominate vein injury to avoid unnecessary damage to the vein. The SCJs overlie the confluence of the internal jugular and subclavian veins. Injury to any vein in this area is unlikely to be fully controlled by endovascular means for several reasons. Achieving balloon tamponade of a vein at a confluence is not usually possible, also vein capacitance is low making balloon occlusion more difficult without excessive balloon inflation pressures which come with a risk of vein rupture.

In the rarer situation of arterial bleeding, it is much easier to achieve endovascular control. The complication consequences of arterial catheterisation are higher with a risk of embolism, significant life-threatening bleeding [49–51] respectively and we would not advocate pre-emptive arterial catheterisation.

Case learning point 6

In two cases of patients with delayed presentation and the medial clavicle in close proximity to innominate vein, a balloon catheter was placed in the vena cava prior to reduction, within the interventional radiology suite.

In case one the femoral vein was catheterised and connected via an extension tubing to a balloon. A test inflation was performed, and cardiothoracic drapes were then placed overlying this. The interventional radiologist would then have been able to

Table 2
First actions to be taken by theatre teams in the presence of bleeding.

Team	
Orthopaedic Surgeon	Alert theatre team, pack with wet swabs, apply pressure
Anaesthetic Team	Tilt head down
Theatre Scrub Team	Activate major haemorrhage protocol Theatre team prepares for thoracotomy
Cardiothoracic Surgeon	Identify site of bleeding and assess need for thoracotomy or further endovascular balloon placement
Interventional radiologist	Inflate endovascular balloon if placed

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inflate the balloon easily under the drapes without disturbing the operative field. (Fig. 4a and b)

In case two the basilic vein was entered on the same side of the operation in this case the palmaris harvest had to be on the contralateral limb. This limited the access options for IV and invasive arterial pressure monitoring for the anaesthetic team, however it is possible for the anaesthetic team to "slave" an arterial trace from the arterial sheath if required. Inflation of the balloon was not required in either case.

Authors have described a reduced trapdoor thoracotomy which allows access to the mediastinal vessels. If there is a known mediastinal injury it is recommended that the initial skin incision for the trap door thoracotomy is made in preparation before any reduction or fixation is attempted [17].

Intra-operative and post operative imaging

Closed reduction position can be confirmed on intraoperative image intensifier using the "Serendipity" view described previously. It is advised that a pre-reduction radiograph is taken to first confirm unobstructed images and if necessary to confirm placement of an endovascular balloon catheter. Fluoroscopy images are often challenging to interpret, and a post operative CT should be completed following manipulation to confirm adequacy of reduction. The use of intra-operative O-arm is becoming more routine in orthopaedic surgery and would obviate the need for postoperative CT scanning and possible return to theatre if reduction is not achieved [52].

Post operative recovery

Following closed reduction, a figure of 8 bandage can be useful in the maintenance posture preventing protraction of the scapula and the potential for re-dislocation, however no evidence is available to demonstrate its superiority to standard sling treatment. In general, our practice is to allow gentle range of movement from two weeks and loading of the shoulder from six weeks. A return to contact sport at five weeks has been observed without complication in one case report of an American footballer [53].

Case learning point 7

Our professional rugby player was weaned off a figure of 8 brace and started jogging, pool work and lower limb weights at 5 weeks. We advised him to avoid compression and cross body flexion. He regained 75% strength at bench press and began return to full play by 5 months. He was unfortunate to sustain and ipsilateral clavicle fracture at 11 months following his injury suggesting his SCJ closed stabilisation was indeed able to withstand full contact sport following injury.

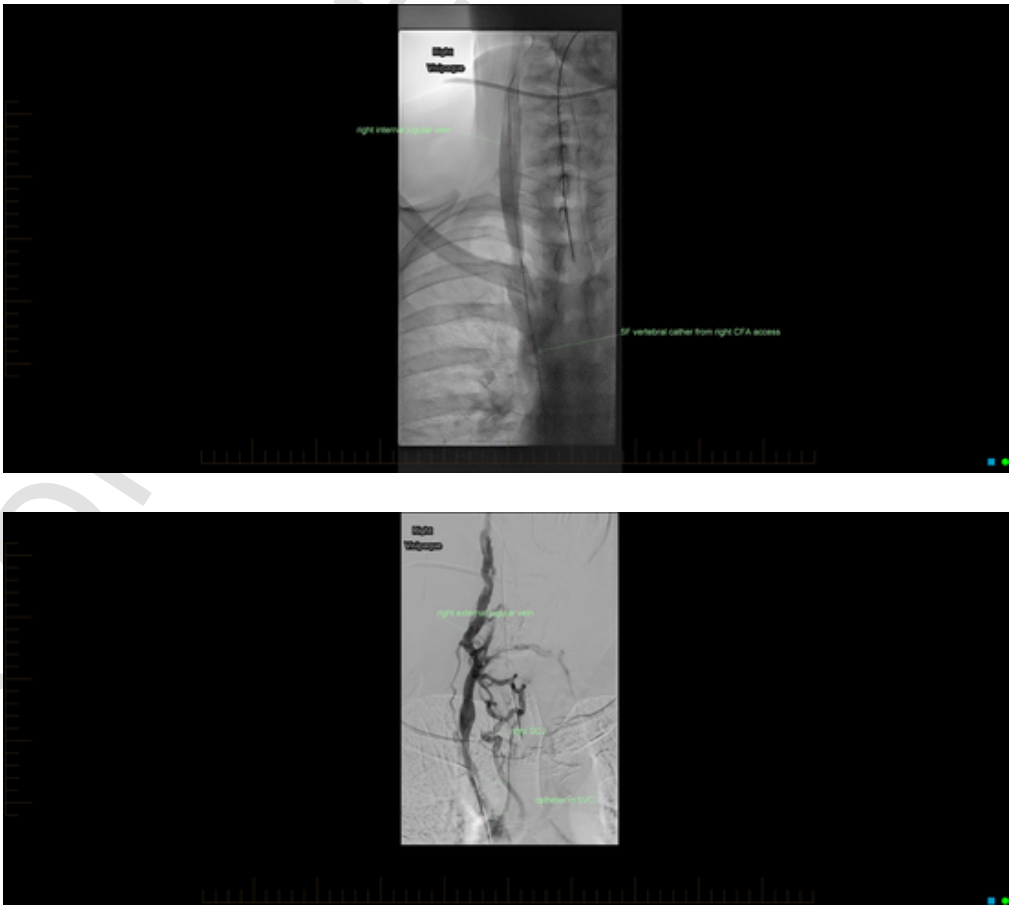

Fig. 4. a and b Images showing placement of catheter in right vena cava from the right femoral vein and contrast within the vertebral venous plexus.

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Post operative complications

Case learning point 8

One of our patients has experienced a stress fracture of the medial clavicle following reconstruction with palmaris graft. This patient had oblique tunnels and a figure of 8 graft configuration and Fibertape® internal brace augment through the same holes. Pain symptoms settled over a period of weeks, but she continued with dysphonia and swallowing discomfort that was present pre-operatively. Anterior to posterior tunnel configuration has the higher theoretical risk of vascular injury but has the best load to failure and has a reduced risk of stress fracture compared to oblique tunnels that exit through the joint [46]

Conclusion

The posterior SCJ dislocation is a potentially life-threatening injury due to massive haemorrhage. We suggest that all posterior SCJ dislocations should be treated in centres with collective experience in managing these injuries with cardiothoracic and interventional radiology support available and present.

Declaration of Competing Interest

None. This is an original publication that has not been submitted elsewhere for publication.

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