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Head and neck hemorrhage: Technical tools and tricks☆

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ABSTRACT

Background: The purpose of the present work is to provide a fresh, simple, and accessible document for all surgeons who treat traumatic hemorrhage from the head and neck.
Methods: This article arose from the work of a consortium of experienced trauma surgeons who collaborated to produce a first-of-its-kind surgical course for multifocal hemorrhage control. The "Bloody Simple Hemorrhage control masterclass course" has been offered at national and international venues since 2019 and has been both well received by participants and well regarded in academic trauma surgical circles. This paper—and the series of articles which accompany it—was meant to be a literature companion to or extension of the *Bloody Simple* course, a way to distill and digest the hemorrhage control strategies espoused therein but in the form of a journal article.
Results: The result of this work is a succinct and experience-based set of principles for conquering life-threatening, traumatic bleeding from a variety of sources in the head and neck.
Conclusion: This article translates experience and evidence into a simple and digestible format that will provide a sound approach for any surgeon facing traumatic hemorrhage from the head and neck.

INTRODUCTION

Hemorrhage from the head and neck is unique in several ways:

(1) Airway patency is often threatened and almost universally a component of hemorrhage control planning.
(2) Cerebral perfusion is of paramount importance. Hemorrhage control and reconstruction must be delicately balanced against risks of ischemia, embolism, and hemorrhagic conversion of established stroke.
(3) Junctions between the thorax and the visceral neck and between the neck and the skull base create challenging hemorrhage control dilemmas that span anatomic regions.

Despite these unique challenges, head and neck hemorrhage remains a very satisfying entity to treat and can be managed successfully with a simple, principled approach that should be familiar to all surgeons who treat traumatic hemorrhage.

AIRWAY CONSIDERATIONS

Establishing an agreed-upon plan for integrating airway management into your hemorrhage control strategy is an immediate priority upon patient arrival to the trauma resuscitation area. Several excellent and comprehensive algorithms are available for this problem [1,2]. However, an even simpler mental model that may help trauma providers and their teams organize their thinking around airway management for head and neck hemorrhage involves asking 2 simple questions: (1) Do I need to control this airway RIGHT NOW? (2) Do I believe that orotracheal intubation stands a high chance of being successful? From these 2 questions, a 2 × 2 decision matrix naturally arises (Fig 1).

In this algorithm, rapid sequence induction (RSI) involves the immediate performance of orotracheal intubation by the most skilled intubator with predetermined doses of amnestic and paralytic medications. A double setup [3] entails the identical, immediate action with the addition of a second proceduralist, standing on the right hand side of the patient with the neck prepped and supplies available for a surgical airway at the ready. In scenarios where airway control is not immediately required, transition to the operating room is appropriate where simple preprocedural intubation can be carried out by the anesthesia team in low-risk circumstance and where an awake tracheostomy can be performed by the operating surgeon when airway difficulties are reasonably anticipated.

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ANATOMIC CLASSIFICATION OF HEAD AND NECK HEMORRHAGE

A major focus of recent literature on head and neck hemorrhage has been to "dezone" the traumatized neck [4]. As authors have sought to develop more comprehensive and universalizable algorithms, they have moved away from the traditional 3-zone approach to neck injury. Although this is undeniably a step forward in some ways, for the individual surgeon facing a given injury, it can still be useful to think of these injuries by general, anatomic locations. By comparing the present injury to similar injuries a surgeon has read about or treated in their past, it allows the operative surgeon to better anticipate what structures are at risk, what pitfalls my await them, and what approaches may prove most beneficial. For this reason, the strategies in this article are presented in anatomic, zonal clusters beginning with the base of the neck and working their way cephalad.

BASE OF NECK/THORACIC INLET HEMORRHAGE

Hemorrhage arising from the base of the neck at the thoracic inlet and extending up to as high as the cricoid cartilage was traditionally referred to as "zone 1" hemorrhage. Irrespective of how one wishes to categorize these injuries, they should be considered injuries to the upper chest and mediastinal great vessels until proven otherwise and treated as such.

Initial control of injuries at the base of the neck can be challenging because of the rigidity of the clavicle and manubrium and the tendency of injured vessels to retract back beneath these bony junctional barriers. To overcome this, the author has made great use of *balloon tamponade* via the insertion of 10 or even 20 mL *Foley catheters* into hemorrhaging wounds and inflating them below the clavicle or sternum. Even grievous injuries to mediastinal venous structures will be universally halted by this approach. The flexibility and utility of Foley balloons cannot be overstated in these scenarios as has been reported in literature from North America and international sources as well as from some of the more luminary names in trauma surgery [5–8].

When arterial hemorrhage arises from the base of the neck, *digital pressure* is typically the only measure that will obtain immediate, even partial control. An educated finger placed by an experienced surgeon may need to be held in place during transition to the operating room, and as in other anatomic zones, that surgeon and their finger may need to be prepped in and exchanged for a sterile compressor once in the OR. One additional consideration at this stage is the use of a modified *Utley maneuver* [9]. In this maneuver, classically described for control of tracheo-innominate fistulae, a finger is inserted and compression of the injured artery is performed by hooking and trapping it against the sternum. Similar techniques can be employed with good effect in desperate situations for neck base hemorrhage.

Surgical exposure in this setting is simple and nearly universal. Although a number of imaginative approaches have been described in this location (trap door, supracalvicular exposures, etc), these are typically technically challenging to perform even in a cadaver course and all the more so in the 4-dimensional scenario of a rapidly exsanguinating patient. Instead, make routine use of a combination of 2 simple and time-tested approaches by combining the *anterior sternocleidomastoid (SCM)* incision with a *median sternotomy* (Fig 2).

This combination of approaches provides commanding exposure of all structures of the superior mediastinum and visceral neck. A surgeon is able to gain proximal arterial control at the level of the aortic arch for all 3 arch vessels, although the left subclavian is admittedly a more difficult origin to control. From this dissection, vascular repairs or ligations can be carried out as appropriate and temporary intravascular shunting performed if physiologic burden of injury dictates against definitive repair.

HEMORRHAGE FROM THE OPERATIVE NECK

One of the most interesting and rewarding experiences for a hemorrhage control surgeon is the opportunity to control bleeding from the so-called operative neck. Classified traditionally as "zone 2," this anatomic region spans roughly the area between the cricoid cartilage and the angle of the mandible. Dissection in this anatomic zone is comparatively straightforward, and structures are both easily identified and relatively forgiving, to a point, as compared to their more proximal and distal aspects at the caudal and cranial junctions of the neck.

Initial control of hemorrhage in this zone is, once again, best obtained with digital pressure or via the insertion of a Foley catheter for

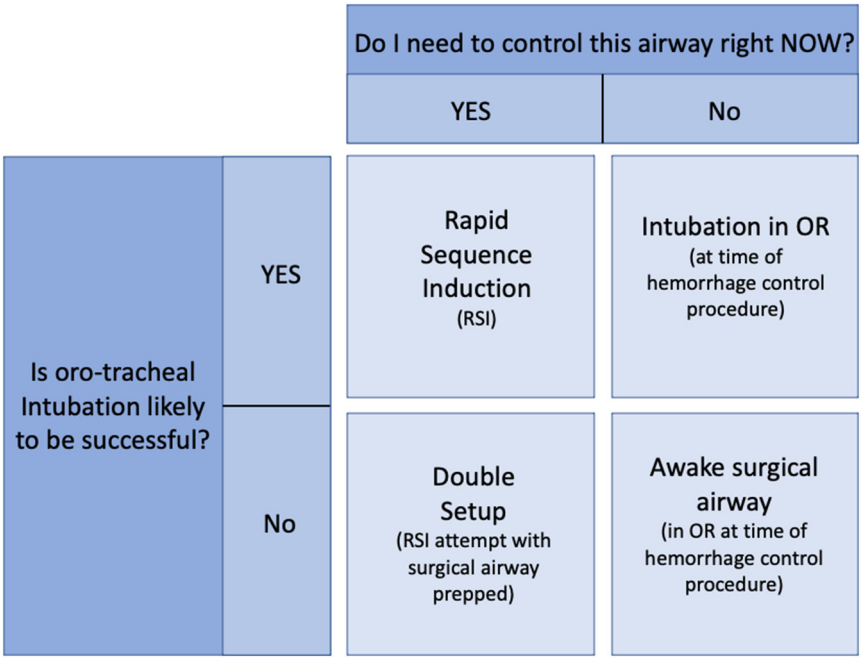

Fig 1. Airway management algorithm for head and neck hemorrhage.

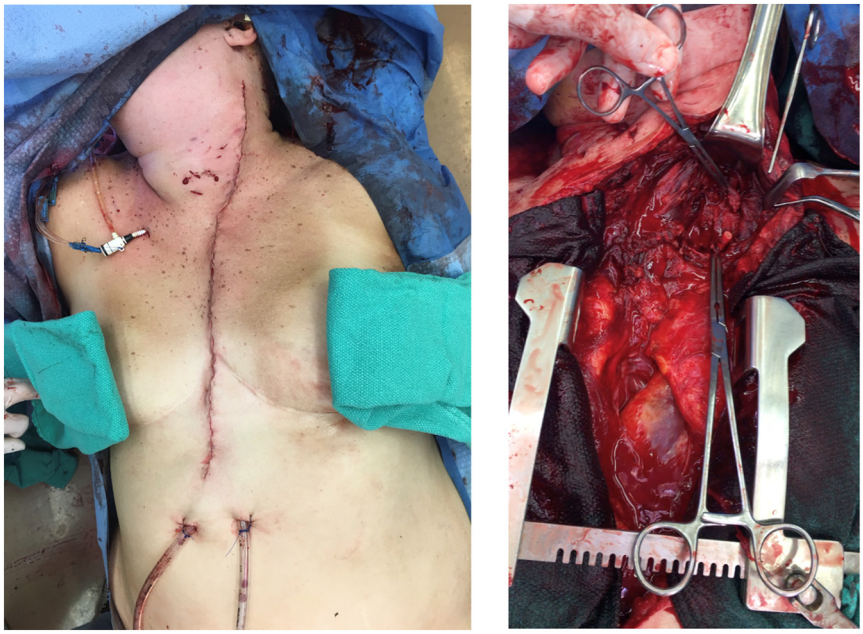

Fig 2. Anterior SCM incision + median sternotomy for exposure of hemorrhage at the base of neck/thoracic inlet junction.

balloon tamponade [5–8]. Special consideration should be given to the fact that injuries in this anatomic zone are most likely to be associated with concomitant airway injury to the larynx or uppermost trachea. The algorithm laid out above for airway management still very much applies, but the surgeon may need to be particularly nimble from a logistic and strategic point of view as surgical airway control and surgical hemorrhage control may need to be performed simultaneously or in very rapid succession for such injuries.

Operative exposure is nearly universally obtained in this anatomic location via the anterior SCM incision with a collar incision being perhaps the only commonly used alternative. To perform an anterior SCM dissection, an extensible incision is made on the anterior border of the muscle, and the SCM itself is rolled laterally and retracted away as the surgeon comes down on and lays open the carotid sheath. Textbook descriptions of this phase of the exploration will typically extol the virtues of following the facial vein back to identify the vascular structures within the sheath. Hemorrhage control surgeons with experience in this area might more accurately say that the injury itself provides the best or at least most sensible guide during this phase. Pulsatile bleeding from the carotid, field-flooding jugular exsanguination or both will typically be what leads the surgeon down along the tip of their finger into the depths of the carotid sheath. The most important consideration for the facial vein is the need to ligate and divide this structure to be able to fully lateralize the jugular vein itself.

Jugular vein injuries can and typically should be ligated with complete impunity in this location. It is the author's preference to have a pair of Debakey forceps in each hand, while assistants are used to provide suction, retraction, and digital compression that is slowly released so that forceps control over the injury can be obtained. From here, Allis clamps and a side biting vascular clamp such as a knuckle-ball Cooley or small Statinsky can be used to control the injury in a fashion that will remind surgeons of control of injuries to the inferior vena cava. At this time, ligation with a vascular suture is typically indicated, although the author has been, at times, tempted into performing lateral repair of even sizeable jugular vein injuries when physiology permits. One key consideration for large jugular injuries, such as the one demonstrated in Figure 3, is air embolism. Taking precautions to avoid entraining air (head-down positioning, immediate vessel compression) is key while exploring these wounds.

Hemorrhage from the carotid artery in this location typically arises from the distal common carotid, the bifurcation, or the proximal aspect of the internal or external carotids. Careful dissection to avoid the vagus nerve is important. In 85% of cases, the vagus will be located posterior to and typically in the groove between jugular vein and common carotid;

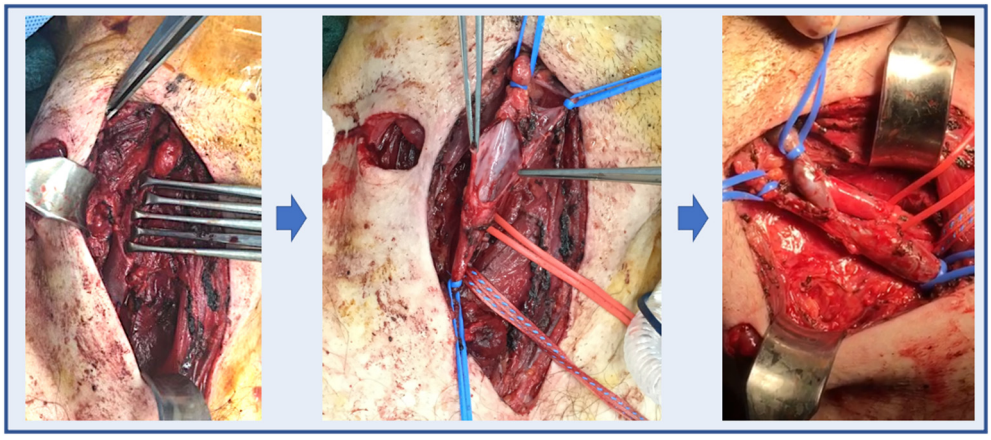

Fig 3. Allis clamp control followed by complete dissection and repair of large caliber jugular venous injury from penetrating trauma.

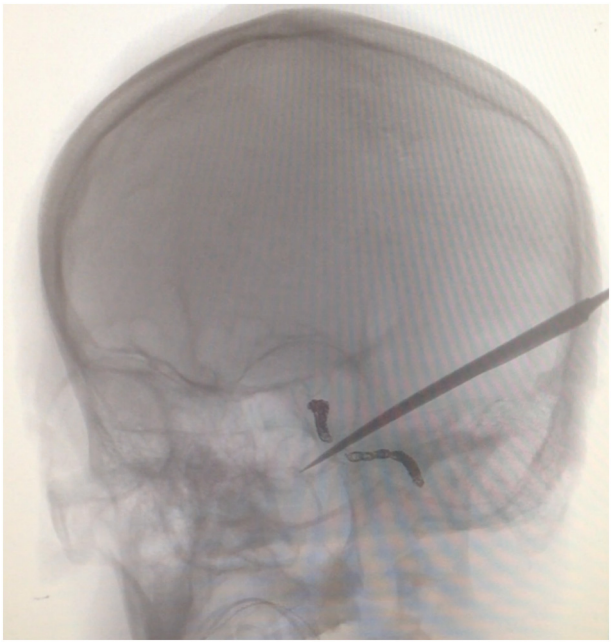

Fig 4. Combined antegrade approach via ipsilateral carotid artery and retrograde approach via contralateral carotid artery and circle of Willis for embolization of skull base carotid injury with retained knife blade in situ.

however, in the remaining 15% of cases, it can be located anterior to the vessels within the sheath. If dissection is required at or slightly above the level of the carotid bifurcation, then attention should be paid to avoiding injury to the hypoglossal nerve as well. However, although injuries to the cranial nerves are important, the dominant concern for hemorrhage control surgeons treating arterial injuries in this location must be the avoidance of a secondary cerebrovascular accident. Because the vessel is so accessible in this location and because bleeding is so evident, it is

Fig 5. Ligation of the external carotid artery as adjunct for severe midface hemorrhage.

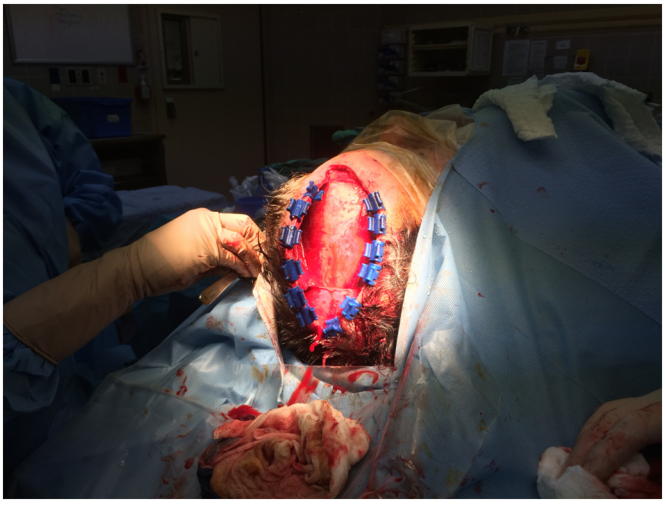

Fig 6. Raney clips applied clinically to an exsanguinating scalp wound prior to definitive repair.

rarely difficult to obtain exposure and arterial control. Once this has been done, typically by the application of straight or angled (45°) proximal and distal vascular clamps, a decision about repair and revascularization technique must be made and executed with skill and alacrity.

When shunting is felt to be indicated, the Argyle shunt is a simple and time-tested tool. When long, prehospital downtimes are present or when an established neurologic deficit is already evident, simple carotid ligation may be the best approach even for the distal common carotid. However, when immediate repair/reconstruction is performed, it is critical to avoid intimal flap creation or distal embolism of air or clot to the internal carotid circulation, at all costs. To this end, all repairs should be done with 5-0 Prolene or smaller, taking bites from inside to outside on the distal segment to "tack up" the distal arterial intima. Similarly, exquisite care must be taken if inserting temporary intravascular shunting to avoid raising intimal dissection flaps. Prior to completion of arteriotomy repair, it is imperative to back bleed to distal vasculature by releasing the clamp. If the bifurcation is involved in the repair, it is similarly critical to release antegrade flow into the external carotid first prior to releasing the distal clamp on the ICA so that small thrombi are preferentially flushed away from cerebral circulation. Closure of all arteriotomies should be done under saline irrigation. For surgeons who do not perform vascular repair regularly, consultation with a senior colleague is highly recommended at this juncture, in particular if interposition vein harvest is required.

SKULL BASE/UPPER CERVICAL HEMORRHAGE

Bleeding arising from the cranial most aspects of the neck, at the junction with the skull base, is one of the most challenging types of hemorrhage to approach surgically. In this anatomic region, often described as "zone 3," traditional surgical exposure is typically only adjunctive to what is most often an endovascular approach to hemorrhage control. Care in a hybrid operating room/interventional radiology suite is highly beneficial for such injuries, as is the acquisition of preoperative computed tomography angiographic imaging if at all possible.

Helpful principles of management for these types of injuries involve the same consideration for thoughtful airway control as elsewhere in the neck. Packing or balloon tamponade can be used for skull-based venous injuries, and where the injuring implement is still in place at the time of injury, this should ideally be left in place until interventional hemorrhage control is immediately available. Bleeding from distal aspects of the vertebral or internal carotid circulation can be intimidating to encounter; however, with modern endovascular techniques, these can almost all be treated. Where direct access and embolization or

stenting are not possible, skilled endovascular providers can access the cerebral circulation from the contralateral side, come over the circle of Willis, and perform retrograde embolization [10] of ipsilateral injury if required (Fig 4). Being mindful of the options available for these extremely surgically inaccessible injuries is perhaps the most important element to add to a hemorrhage control surgeon's mental tool box.

MIDFACE, OROPHARYNGEAL, AND SCALP HEMORRHAGE

Although hemorrhage control surgeons typically enjoy working in the neck, bleeding arising from the oropharynx and midface can present a truly daunting challenge because their knowledge of the anatomy and fluency with operating in this region can be minimal. Thankfully, simple approaches are often effective and relatively easy to deploy.

Oropharyngeal and midface hemorrhage from severe blunt trauma or transoral/transfacial gunshot wounds can be formidable. Arterial epistaxis, airway-threatening intraoral hemorrhage, and impressive external bleeding from traumatic facial defects can present individually or in combination, and treating these injuries well requires immediate, definitive action. First, surgeons should turn their attention to airway considerations because a secure airway, often a surgical airway, is the best initial approach to permit good oropharyngeal and midface hemorrhage control. Once an airway is established, the surgeon's best ally will be tight, intracavitary packing of all bleeding sites. The mouth and throat can be occlusively packed with 1-in. thick ribbon gauze with radiopaque marker (throat pack), and the nasal cavities can be filled with ¼" gauze using bayonet forceps, reinforced with Foley catheters inserted anteriorly and inflated in the nasopharynx. Finally, if tight packing of oral cavity, nasal cavity, and traumatic wound cavities does not provide adequate temporary control, then surgical selective ligation of the external carotid artery can be used with relatively little difficulty, once again using an anterior SCM incision to access the vessel (Fig 5).

Bleeding from the scalp is neither a trivial source of blood loss nor by any means a form of bleeding which is below or somehow outside the scope of a hemorrhage control surgeon. Far forward and prehospital providers tend to underestimate the impact of and generally undertreat scalp and cranial bleeding. Bulky gauze dressings are often applied which only serve to obscure bleeding from view. Minimally efficacious techniques such as mostly blind stapling of blood-soaked, hair-matted scalp is too often used. The net result of these approaches is that shocked and exsanguinating patients continue to soak the sheets of the stretcher or operating room table with blood from scalp wounds that are deprioritized or nearly completely overlooked.

If recognition is the first step in treating these injuries, then a thorough suture repair under operating room conditions is often the second and definitive step. Good washout, deep suturing of bleeders off the Galea, and closure with a heavyweight locking suture are often all that are required. Of important note, in situations with other pressing hemorrhage control needs, scalp bleeding can be rapidly temporized by the use of neurosurgical Raney clips (Fig 6). These clips are designed for use during craniotomy to control impressive bleeding from the cut edge of the scalp. They are easy to deploy and provide similarly excellent control of traumatic hemorrhage as they do for neurosurgical bleeding.

SUMMARY

In conclusion, massive ongoing hemorrhage from the head and neck presents several unique challenges including the need for nuanced and immediate airway management planning, a focus on cerebral perfusion, and the difficulties associated with working around junctional zones in the upper mediastinum and skull base. A stepwise and rationale approach to these injuries is important and will typically lead to satisfying and straightforward solutions to all but the most complex problems.

Although the experience of the average hemorrhage control surgeon may be waning as it relates to head and neck hemorrhage, the skills required for effective surgical management are all transferable from other fields of surgical exploration. Choosing the appropriate approach or combination of approaches is key. Using colleagues from associated fields such as airway experts (anesthesia) and those with advanced endovascular skills (interventional radiology/vascular surgery) is often critical for safe and successful patient management. However, hemorrhage control surgeons who "consult away" the bulk of this work to surgeons with daytime, specialist practices will find themselves all too often unhappy with the outcomes for the patients and increasingly uncomfortable with managing this not uncommon subset of life-threatening hemorrhage. A rational approach to this problem with appropriate engagement of specialist colleagues is the key to safe and successful management of head and neck hemorrhage.

Author Contribution

Dr Leeper wrote and edited all components of this manuscript.

Conflict of Interest

Dr Leeper has no conflicts of interest to declare.

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Ethics Approval

No patient data or identifiable patient information was included in this manuscript. No ethics approval was obtained.

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