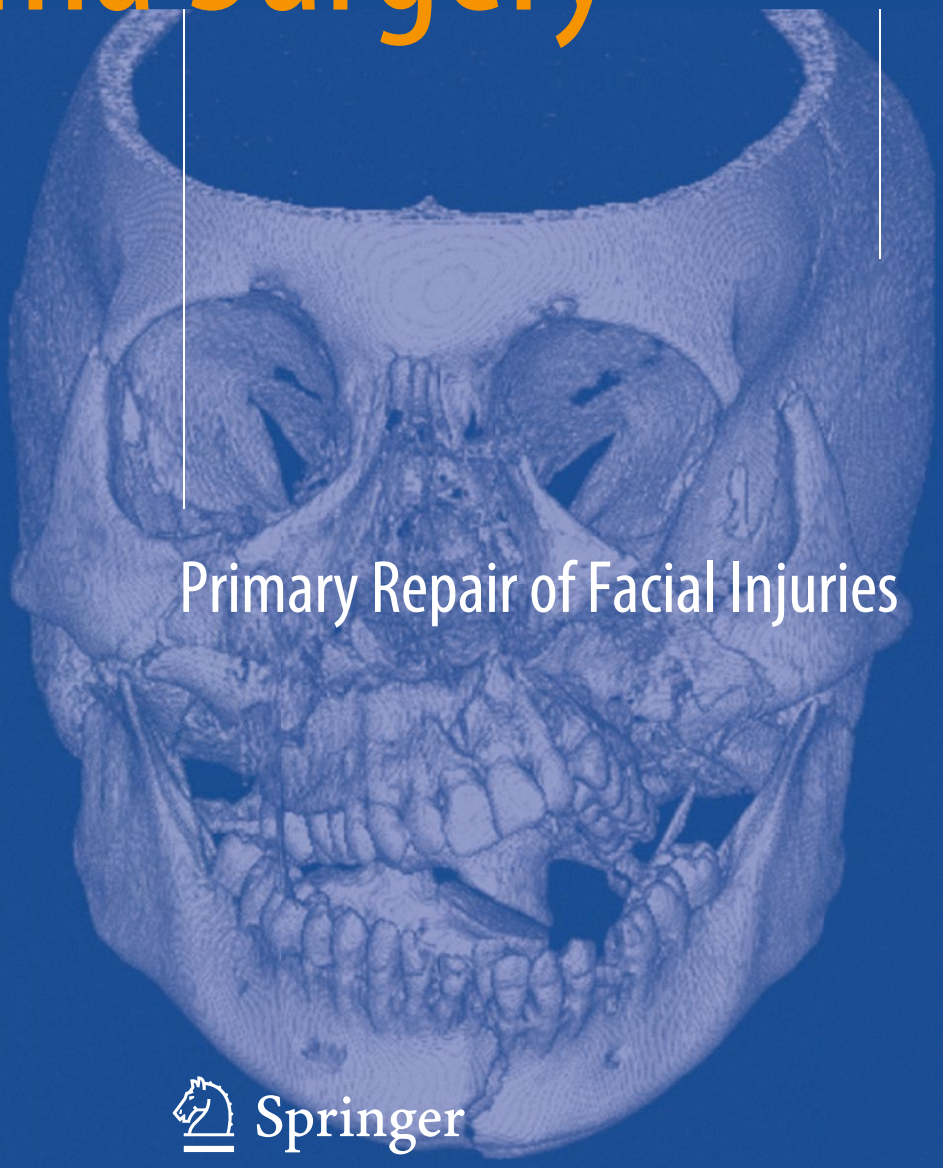
Michael Perry · Simon Holmes
Editors

Atlas of Operative Maxillofacial Trauma Surgery



Primary Repair of Facial Injuries

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Preface

Craniofacial trauma, in all its forms, is a challenging area of clinical practice, even in the twenty-first century. This is in part due to the highly visible effects it has on both the function and aesthetics of the face. Even "minor" injuries can result in significant disability and unsightly appearances if not precisely repaired. Although many facial injuries occur following relatively low-energy impacts (and can therefore be treated satisfactorily in many patients), the goal of *consistently returning our patients precisely to their pre-injury form and function* still eludes us—*if* we critically review our results. This is especially likely when high-energy injuries have resulted in both comminution of the facial skeleton and significant soft tissue damage.

"Key" areas, or sites, considered of great importance in the repair of facial injuries are now well recognised and have been reported widely. There have also been major developments in the fields of tissue healing, biomaterials, and surgical technology, all of which have helped improve outcomes. In many respects, parallels can be drawn with orthopaedic surgery. Management of facial trauma in a sense can be regarded as "facial orthopaedics." Both specialities share the same common core knowledge and apply similar management principles, notably in fracture healing, principles of fixation, and an appreciation of the "soft tissue envelope." However, one would hope that we can additionally draw on our aesthetic skills, as facial surgeons, to get the best possible results in our patients.

Some "Key" Areas in Repair
Medial canthal position
Posterior medial "bulge" of orbital floor
Lateral orbital wall (alignment with greater wing of sphenoid)
Posterior facial height (condyle)
Posterior wall of frontal sinus/dural integrity
Frontal-nasal duct patency
Nasal projection
The zygomatic arch
Occlusion
Wound closure
Soft tissue drape
Anatomical boundaries (e.g., vermillion border, eyebrow)
Lacrimal apparatus
Eyelid margins

The aim of this book is to provide a framework upon which surgeons in training, or those who manage trauma infrequently, can develop skills in assessment, treatment planning, and then (hopefully) repair of facial injuries. Many excellent texts already exist and the aim of this book is to complement these by focussing on the technical aspects. It is of course only a starting point and certainly not intended as a substitute for structured training and experience.

This is a book of "options." As with many areas in medicine and surgery, there are "many ways to skin a cat" and repairing facial injuries is no different. Many injuries can be managed

in more than one way and using more than one method. We have tried to illustrate this. Many techniques outlined in this book will have modifications, or variations. Furthermore, management of some injuries is still very controversial, as we have tried to point out. Although we have endeavoured to cover as much ground as possible, we do accept that this book is by no means totally comprehensive—probably no book ever will be. Nevertheless, we hope this will form a useful foundation for some.

A few quick notes: The images used in this book have been taken over the past decade or so, and perhaps not surprisingly their quality has improved accordingly from those taken with the old-style Polaroid films to the more "state of the art" digital camera. Either way, we hope the quality is sufficient. The references have been chosen on the basis of interest rather than any attempt to be comprehensive. Finally, to get the most out of this book, the reader should ideally have some basic knowledge of anatomy and an understanding of trauma care and basic surgical principles.

Michael Perry
Simon Holmes

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Many people have contributed to this book both directly and indirectly. Without their involvement this would not have been possible.

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Depuy Synthes Medical Ireland, Tekno Surgical, and KLS Martin for providing images of their products and supporting production of this book.

We would also like to thank our past trainers and other colleagues, without whom we may never had developed our interests, skills, and knowledge in trauma care. As Isaac Newton once wrote: “If I have seen further it is by standing on the shoulders of giants.”

And, finally, we would like to thank the many hundreds of patients (many of whom remain anonymous) who have so kindly allowed us to use the pictures we have taken. Without them this book would not have been possible and it is to them that we dedicate this book, with our heartfelt gratitude.

June 2014 Michael Perry

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1 Initial Considerations: High- vs. Low-Energy Injuries and the Implications of Coexisting Multiple Injuries

Michael Perry and Steve White

1.1 Introduction

Injuries to the face vary widely in severity. They range from the most trivial to those associated with life-threatening complications. Although in most cases such complications are immediately apparent when the patient is first seen, occasionally they can be concealed, or they can develop gradually over a period of several hours. Airway obstruction from progressive swelling is an example of this. Injuries to the face can either occur in isolation, or they can be associated with significant injuries elsewhere on the patient, some of which may also go unnoticed initially. In some facial or head injuries, sight-threatening complications may also be associated. These, too, may not be immediately obvious. Initial assessment and management can therefore be very challenging, as all these variables need to be taken into account. This is particularly the case following high-energy trauma when multiple injuries are more likely to have occurred.

Unfortunately, the presence of coexisting injuries (or even their suspicion) can have a significant effect on the patient's overall management. Not only can these affect *our* ideal goals in planning treatment, but they can also affect those of other specialties. Even relatively "simple" decisions may not be as straightforward as we would like (*e.g.*, "should we intubate the patient before going to CT, or wait and see what the scan shows?"). Such decision-making is also influenced by local circumstances (available resources, clinical experience, concern for other injuries, and need for transfer).

A team approach is therefore of vital importance, particularly in the early stages of management, when the clinical status of the patient and the need for regular reassessment and intervention are often at their most dynamic. Protocol-driven management is now a well-established concept, and when available, local guidelines should always be followed.

Whenever facial injuries coexist with injuries to the torso, a number of clinical dilemmas commonly arise. A few examples are shown (*see* Table 1.1).

Depending on the injuries present (or even if they are just suspected), one or more of these dilemmas may arise early in the patient's management. As a general observation, the most challenging patients are those with associated head, torso, or spinal injuries, or those patients who present in profound hypovolaemic shock, without an obvious cause. However, even the most "straightforward" of cases can rapidly deteriorate if occult (hidden) injuries remain unrecognised for too long. Injuries to the torso (especially the chest) can significantly affect the timing of surgery, particularly if this is delayed. As surgeons, we need to be aware of all these issues—failure to recognise them may greatly influence outcomes.

Table 1.1 Some common clinical dilemmas when facial injuries coexist with injuries to the torso

Appropriate airway management in restrained supine patients
Management of sudden and unexpected vomiting in restrained supine patients
Clearing cervical spine injuries
"Can I sit up?": the impact of *potential* torso and spinal injuries on allowing patients to protect their own airway
Permissive hypotension and diagnosing facial haemorrhage
Damage control and its effect on the timing of definitive repair
The implications of coexisting skull base or brain injuries
Diagnosing vision-threatening injuries in unconscious patients
Management of the proptosed globe

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1.2 Establishing Clinical Priorities and Triaging Facial Injuries

From our perspective, "emergency care" in facial trauma effectively means airway management, control of profuse bleeding, and the management of vision-threatening injuries (VTI). The management of life-threatening head injuries is outside our area of expertise and requires urgent neurosurgical intervention.

Although true maxillofacial and ophthalmic "emergencies" are uncommon (*i.e.*, complications of facial injuries that require immediate identification and/or management, to preserve life or sight), it is nevertheless important to remember that they can occur any time over a relatively protracted period. They can also occur following relatively minor injuries (*see* Fig. 1.1).

Anticipation is the key to management—some complications may take a while to become clinically apparent. It is therefore important to be aware of early warning signs. It is also important to appreciate the manner in which these complications can potentially affect the patient's overall management. Any risk factors should be identified and noted (*e.g.*, intoxicated patients, or patients taking anticoagulants) (*see* Fig. 1.2).

From a maxillofacial perspective, "emergency care" effectively means

1. Airway management,
2. Control of profuse bleeding and
3. Management of vision-threatening injuries (VTI)

Although head injuries clearly fall within a trauma context, their management is outside our area of expertise, thus requiring the help of our neurosurgical colleagues. These injuries will not be discussed in detail, although an awareness and understanding of their pathophysiology, diagnosis, and management is essential to all trauma physicians.

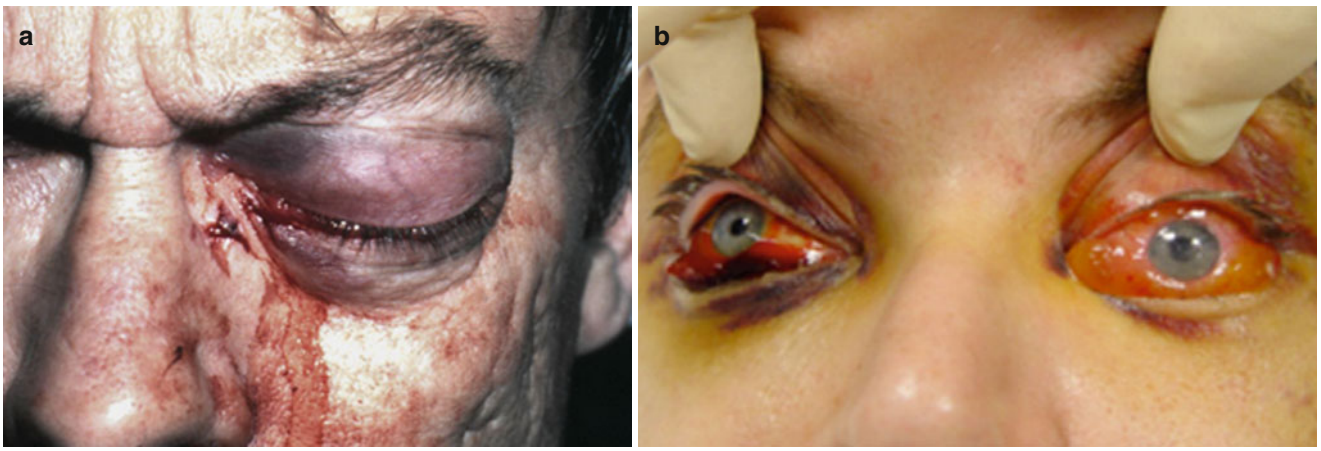

Fig. 1.1 Acute proptosis within 1 h of injury (**a**) and progressive proptosis after 48 h (**b**). Both are vision-threatening, secondary to oedema. The acute proptosis required urgent surgical decompression

Fig. 1.2 Acute proptosis following a penetrating injury, resulting in a retrobulbar haemorrhage (*see also* Fig. 1.51)

Failure to rapidly recognise and manage any of these emergent conditions can result in loss of life or sight. However, if *none* of these are present, detailed assessment of most facial injuries can usually wait a short while, if necessary. This will enable the comprehensive assessment of the entire patient. All injuries, both above and below the collar bones, need to be rapidly recognised, prioritized, and then managed in a timely and coordinated manner. Unfortunately, priorities can suddenly change, as injuries or other events evolve and become clinically evident (*e.g.*, the development of a compartment syndrome, falling level of consciousness, or unexpected vomiting). Assessment therefore needs to be both systematic *and repeated*, with anticipation of all these potential developments.

From a practical point of view, facial injuries can be broadly placed into one of four groups, based on the urgency of treatment required (Table 1.2).

Life and sight-threatening complications can occur following apparently trivial injuries. As such they may not be initially considered.

Table 1.2 Triaging facial injuries

Most facial injuries can be placed into one of four groups:
1. **Immediate** life- or sight-saving treatment is required, *e.g.*, surgical airway, control of profuse haemorrhage, or a lateral canthotomy and cantholysis.
2. Treatment is required within **a few hours**. This applies to clinically "urgent" injuries, such as heavily contaminated wounds and some contaminated open fractures (especially skull fractures with exposed dura). The patient is otherwise clinically stable.
3. Treatment can **wait 24 h** if necessary (some fractures and clean lacerations).
4. Treatment can wait **over 24 h** if necessary (most fractures).
Put another way, for each of the above groups, intervention is needed:
Within a few seconds
Within a few hours
Within a few days
Within a few weeks

When assessing injuries above the collar bones, consider them under four main anatomic subheadings:

- The Brain
- The Neck
- The Eyes
- The Face

If there is an obvious injury in one site, ask yourself "Could there be associated injuries in any of the others?" The mechanism of injury may suggest the possibility of occult injuries that may need further detailed investigation (discussed later) (*see* Figs. 1.3 and 1.4).

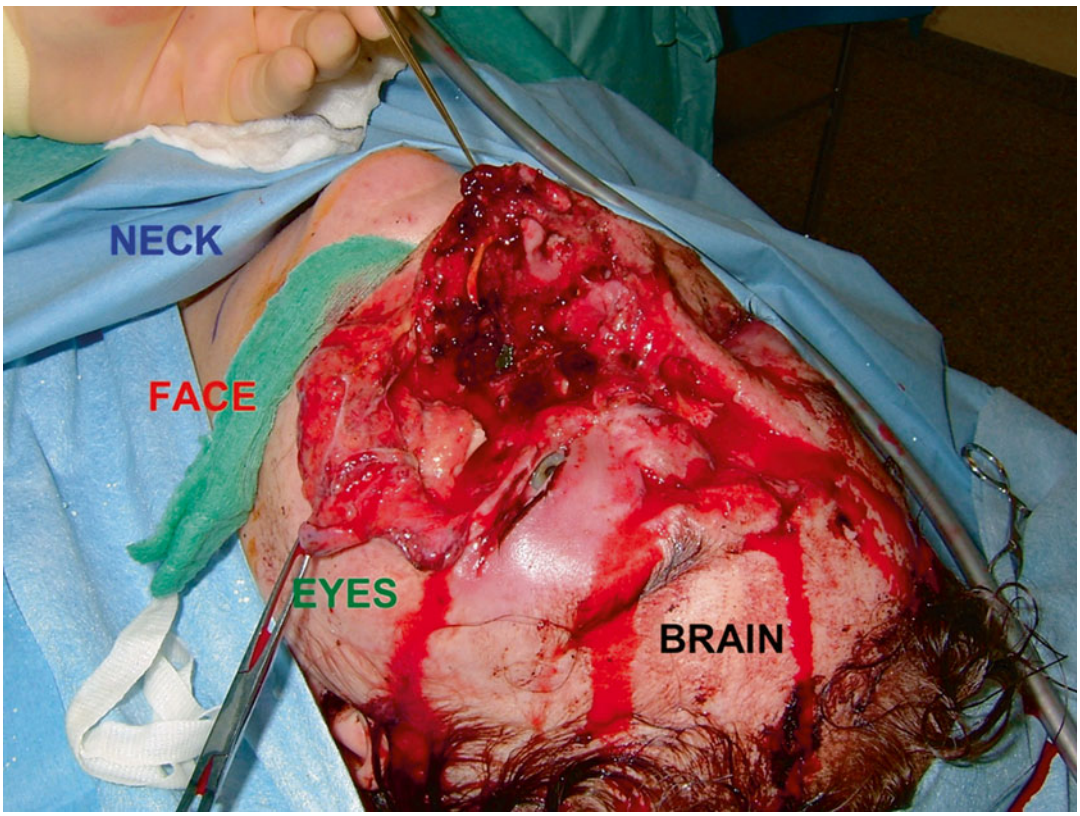

Fig. 1.3 Obvious facial injuries following a high-speed motor vehicle collision. The brain, eyes, and cervical spine require careful evaluation

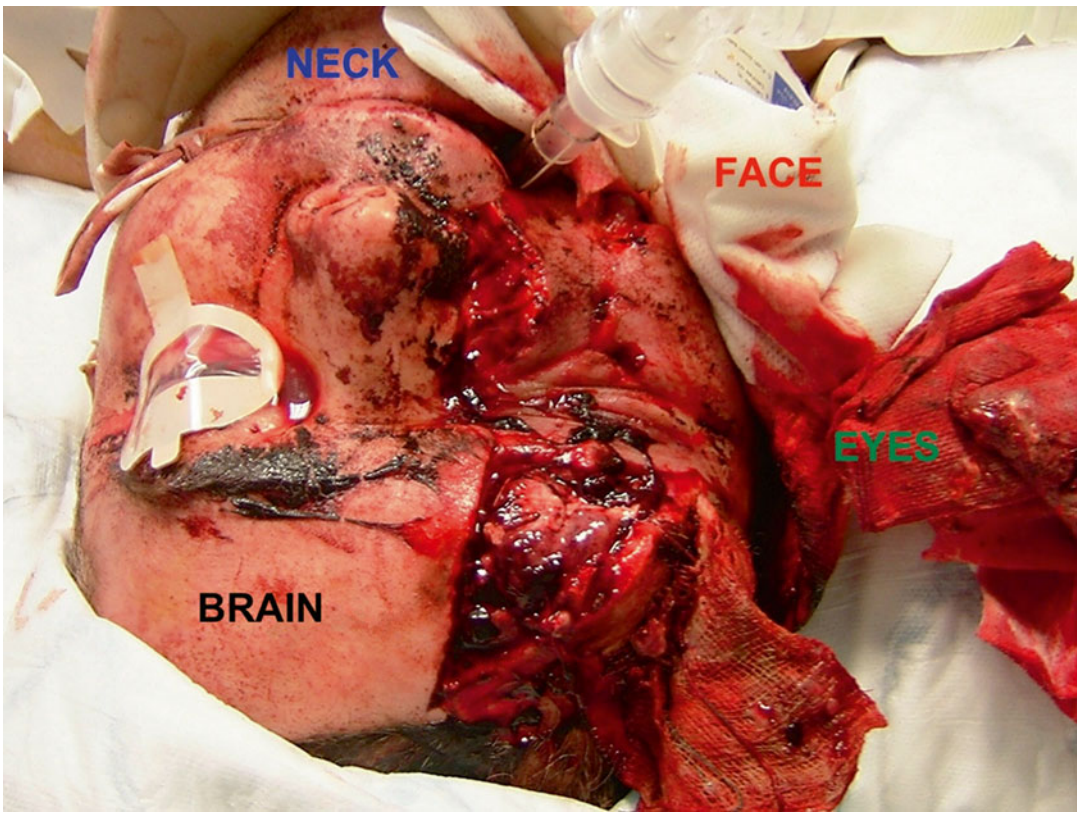

Fig. 1.4 Obvious injuries to the face and forehead with exposed brain and rupture of the globe. Remember the cervical spine as part of the assessment

1.3 Advanced Trauma Life Support™ and Facial Injuries

Facial surgeons should ideally be an integral part of the trauma team when facial injuries are evident. Advice or interventions are frequently required. This is particularly relevant in the management of:

1. The airway
2. Hypovolaemia and facial bleeding
3. Craniofacial injuries
4. Initial assessment of the eyes

Advanced Trauma Life Support (ATLS™) has generally become accepted as the gold standard in the initial management of the multiply injured patient and is now taught in more than 50 countries worldwide. It is based on a number of well-established principles (*see* Table 1.3).

Resuscitation and management of life-threatening injuries are undertaken as quickly as possible; hence the term "golden hour." However, there is no evidence to show that survivability rapidly declines specifically after 60 min. The term "golden hour" is simply an expression used to highlight the need for rapid intervention—time is of the essence. Understanding the mechanism of injury is another very useful concept. This helps us suspect the presence of occult injuries. "Deceleration" injuries (when the patient comes to an abrupt stop) are a good example of this. Interestingly, this understanding of the mechanism of injury is not new. Hippocrates is reported to have first noted the association between blunt facial trauma and blindness around 400 BC, while in 1557, Vesalius noted disruption of the thoracic aorta in a man following a fall from a horse.

Advanced Trauma Life Support™ provides a systematic approach that should ensure that life-threatening and subsequent injuries are identified and managed in an appropriate and timely manner. Unfortunately, when injuries to the face coexist in the multiply injured patient, decision-making may not be as simple as we would like. This is for several reasons:

1. ***Clinical priorities can conflict***. Following completion of the primary survey (a rapid process aimed at "treating the greatest threat to life first"), all the patient's injuries (and clinical developments) then require further evaluation and definitive management. These may be difficult to prioritise, particularly in patients who have sustained significant facial injuries. Two examples are given in Tables 1.4 and 1.5.
2. ***Clinical priorities can suddenly change***. The patient's blood pressure, oxygen saturation, or Glasgow coma scale (GCS) may suddenly fall for no obvious reason. This requires immediate reassessment. Unexpected vomiting during transfer, or in the radiology department or computed tomography (CT) scanner, is potentially a common problem in all patients with facial injuries. But does this mean that the airway should be secured in all patients *just in case* they vomit? If so, when should they be extubated? This consideration would need to include patients with relatively minor facial injuries as well as those who are just clearly intoxicated.
3. ***Clinical priorities can be hidden***. This is particularly relevant in the mediastinum and retroperitoneum following deceleration injuries. Some injuries (*e.g.*, carotid and upper aerodigestive tract), are relatively uncommon and therefore may not be initially considered in the emergency department. Cardiac contusion following chest trauma can be misdiagnosed as musculoskeletal pain. Yet all these injuries (and many others) carry significant morbidity and mortality if missed. From a maxillofacial

Table 1.3 Advanced trauma life support™ principles

ABCDEs of assessment (***A***irway control with cervical spine protection, ***B***reathing with ventilation, **C**irculation with haemorrhage control, **D**isability—neurological status, and **E**xposure/**E**nvironment)
"Primum non nocere" (first, do no harm)
The concept of the "golden hour"
The need for frequent reassessment, for evolving injuries
The importance of the mechanism of injury

Table 1.4 Clinical dilemma 1

What is the best way to manage an alert patient with significant facial injuries (placing the airway at risk), who repeatedly wants to sit up, but who (based on the mechanism of injury), may *possibly* have spinal or pelvic injuries?
Option 1. Endotracheal intubation would secure the airway, but results in loss of the ability to regularly reassess the patient clinically (level of consciousness/can they still see?/is the abdomen becoming tender?/could they be developing a compartment syndrome?/can they "wiggle" their toes?)
Option 2. Maintaining the airway in an immobilised patient facilitates repeated clinical assessment, but places them at risk from unexpected and sudden vomiting.
Option 3. Sitting the patient up (to protect the airway) puts the spine at risk and may displace pelvic fractures.

Table 1.5 Clinical dilemma 2

How do we manage a "stoney hard" proptosis in a patient requiring immediate laparotomy?
Option 1. Should surgical decompression be attempted in theatre in the absence of a precise diagnosis (bearing in mind that time is against us)?
Option 2. Should surgery be deferred until CT scans of the orbit have been done? (Is the proptosis secondary to blood, bone, air, oedema or frontal lobe herniation? Are there any mobile bone fragments around the orbital apex?)

perspective, how do we rapidly diagnose (or perhaps more pertinently, confidently *exclude*) a vision-threatening injury requiring immediate intervention, or blindness in the unconscious patient?

It is not just patients with major facial injuries that present these dilemmas. Those with relatively *minor* facial injuries can still be problematic due to poor cooperation, vomiting, or simply being too intoxicated to assess thoroughly. Alcohol, brain injury, and facial bleeding are commonly associated with facial injuries in many countries. Potentially these can result in major problems if the patient vomits unexpectedly while under spinal immobilisation and inadequate supervision.

These are just a few clinical scenarios we may have to deal with when treating patients with multiple injuries and injuries to the face. For most scenarios there is usually no right or wrong answer. Many factors need to be taken into consideration and the pros and cons of each option quickly considered. Experience is extremely valuable and one should never be reluctant to seek it.

Many heads are better than one—a team approach is invaluable.

Facial injuries complicate the overall management of the multiply injured patient because they present their own set of clinical priorities. These need to be carefully balanced against actual *or potential* injuries elsewhere, some of which may take greater priority. Injuries elsewhere may greatly influence the management of facial injuries, notably timing of definitive repair.

1.4 Understanding Mechanisms of Injury

The possibility of delayed onset of life-threatening complications is particularly important when interhospital transfers for specialist treatment is being considered.

Knowing the mechanism of injury in a trauma patient is very helpful during initial assessment. Often it can provide important clues to the possibility of associated and sometimes occult injuries. Up to 15 % of all injuries (particularly spinal and orthopaedic) have been reported to go unrecognised following initial assessment. Some autopsy studies have shown an even higher percentage. Specific injury patterns are now well known to be associated with certain injuring mechanisms. A few examples of these are listed in Table 1.6.

Table 1.6 Interpreting mechanisms of injury

A fall from a height of ≥10 ft carries an increased risk of sustaining spinal, pelvic, and long-bone injuries.
Anteroposterior crushing forces can result in mediastinal compression ("shoveling effect" or "osseous pinch").
Deceleration injuries can result in shearing forces across pedicled viscera, which can tear. In the thorax (mediastinum) this is known as the "bell clanger" effect. Calculations have shown that a surprisingly low instantaneous deceleration has the potential to kill due to this effect; viscera and organs can partially or totally avulse their vascular pedicles, resulting in catastrophic haemorrhage.
Blast injuries can result in tension pneumothorax or major pulmonary contusions, even in the absence of external signs of injury.
Blunt trauma to the forehead can result in blindness, even in the absence of fractures.
A blow directly on the chin can result in the well-known "guardsmans" fracture, or an injury to the brain stem.
Anterior-posterior–directed forces to the face can result in hyperextension injuries to the cervical spine and spinal cord injury (notably in the elderly)
Many other examples exist. Crudely speaking, injuries occur as a result of varying combinations of compression, distraction, overpressure, cavitation, and shearing forces.

Unfortunately, some injuries may not be *immediately* apparent and can take hours, or even days, to become clinically detectable (*see* Figs. 1.5 and 1.6). Aortic dissection, for instance, can remain relatively symptom free initially, only to kill the patient a few days later. Delayed onset of these life threatening complications is particularly important when interhospital transfer to specialist units is being considered.

Fig. 1.5 This elderly patient was seen as an outpatient, having tripped and fallen flat on her face. In addition to her facial injuries she was also complaining of some mild weakness in her right hand. MRI confirmed a central cord syndrome. The clue is the mechanism of injury, which resulted in hyperextension of the neck

Fig. 1.6 Angiogram demonstrating a tear in the aorta. This occurred following a deceleration injury. Rapid deceleration can result in life-threatening mediastinal injuries

For these reasons, many life-threatening injuries (notably mediastinal), are now actively screened for, rather than adopting a "wait-and-see" policy. In many trauma centers, indications for imaging (usually CT) now include the mechanism of injury, in addition to clinical signs. Clinical examination of the chest and abdomen is generally accepted as unreliable in the trauma setting and imaging is now frequently undertaken. However, this may result in the need to urgently transfer patients with facial injuries out of the relative safety of the emergency department, potentially with an "at risk" airway, or unrecognised facial bleeding. The risks and benefits of urgent intubation prior to transfer therefore need to be quickly weighed up.

Fortunately, with the newer high-speed scanners currently available, CT of the facial bones should now be possible at the same time as CT imaging elsewhere on the patient. Only in those patients requiring immediate life-saving interventions should this be deferred. Imaging of the face along with the rest of the torso avoids further transfers later on. It also avoids potential delays in the diagnosis, planning and subsequent treatment of the facial injuries.

1.5 Initial Assessment in Facial Trauma

All clinicians involved in trauma management should be competent in carrying out a primary survey and initiating resuscitative procedures. When facial injuries are present, this particularly involves specialist airway management and control of facial bleeding. Early consideration of vision-threatening injuries is also important, but this should not distract from the initial assessment and resuscitation.

1.5.1 Airway, with Control of Cervical Spine

In all trauma patients, the first priority is to quickly assess the airway, while at the same time protecting the cervical spine (*see* Table 1.7).

During assessment, the cervical spine should be immobilised, either manually by an assistant, or by using a hard collar, blocks, and straps. However, combative patients may only tolerate a hard collar. Forceful restraint of the head in a thrashing patient simply creates a fulcrum with leverage on the neck as the rest of the body moves. In such cases, if the patient does not quickly settle with oxygenation, correction of hypovolaemia and pain relief, then formal anaesthesia with intubation and ventilation must be considered. This is considered safer than sedating the patient without providing definitive airway control.

It is important to remember that the "airway" is not just the mouth. Obstruction may occur at any point from the lips and nostrils to the carina. Many factors can contribute to airway compromise, notably a fall in the consciousness level. This is most commonly associated with alcohol and brain injury. Obstruction may arise from foreign bodies (food, dentures, teeth, blood and secretions) or displaced/swollen tissues. The most common obstructing materials in facial injuries are blood and vomit. Trauma to the front of the neck (bicycle injuries, automobile crashes, falls, sports injuries, clothesline injuries, and hanging) can also result in direct injury to the upper airway and occasionally expanding haematoma.

Obstruction is an ever-present risk in almost all patients with significant facial injuries. Blood and secretions can collect in the pharynx, especially when they are supine. In most awake patients, this is simply swallowed. However, when midface or mandibular fractures are present, swallowing may be painful and ineffective in keeping the airway clear. Early signs of partial obstruction may be easily overlooked, particularly in patients who are intoxicated or have an associated brain injury. Not only are these patients at risk of vomiting, but any reduction in consciousness further impairs protective airway reflexes. Care must be taken if these patients are positioned supine.

Table 1.7 Airway assessment following facial injury

This usually starts by trying to elicit a verbal response: "what happened?" or "how do you feel?"
Although an appropriate reply is encouraging, direct inspection of the oropharynx for bleeding or loose or foreign bodies is still important (after all, most of us can easily talk with food or chewing gum in our mouths).
Significant bleeding may not be obvious in the supine patient if they are awake enough to swallow their blood. This will only be recognised by direct inspection of the pharynx—take a good look.
Retropharyngeal haematoma (secondary to a cervical spine injury) can occasionally result in airway obstruction. If it is present, consider the possibility of an unstable fracture.
Any suctioning of the pharynx should be undertaken carefully in awake patients. Stimulation of the soft palate and pharynx can trigger vomiting.
Consider the mechanism of injury to the face—is major swelling likely to occur?
Is the mandible intact, or is there loss of tongue support?

It is therefore important to identify oral or nasal bleeding early, even in the alert patient. If not, swallowed blood will accumulate in the stomach, resulting in nausea and a risk of unexpected vomiting (perhaps later on, when the patient is less well attended by staff). Alcohol intoxication complicates matters further as it is well known to result in loss of consciousness and vomiting.

It is important to identify oral or nasal bleeding even in the alert patient. If not, swallowed blood will accumulate in the stomach, resulting in nausea and a risk of unexpected vomiting.

1.5.2 "Can I Sit Up?"

Patients should never be forced or restrained onto their backs—this is more likely to compromise both the airway and any spinal injury.

When facial injuries are present in supine patients (and sometimes when they are not), it is important to recognise the implications of repeated requests or attempts by the

patient to sit up. Although agitation is a common cause, attempts to get up may also indicate a desire to vomit, or that there is partial airway obstruction from foreign bodies, swelling, loss of tongue support or bleeding. Patients may try to sit themselves forwards and drool, thereby allowing blood and secretions to drain from the mouth (*see* Fig. 1.7).

However, this position is clearly at variance to ATLS teaching: "Proper immobilisation is achieved with the patient in the neutral position, *i.e.*, supine without rotating or bending the spinal column." "Cervical spine injury requires continuous immobilisation of the entire patient with a semirigid cervical collar, backboard, tape and straps before and during transfer to a definitive care facility." Patients may therefore arrive in the emergency department securely strapped to a spine board. If the straps are released and the patient is allowed to sit up, this will axially load the spine and pelvis, potentially displacing fractures. This loading will occur even if the head is supported. The dilemma here is, when is it safe to allow this? And if it is not safe, what should be done (and how soon)? (*see* Fig. 1.8.)

Whether to allow such patients to sit up (or not) therefore depends on a number of factors that need to be carefully and quickly weighed up (*see* Table 1.8).

Careful assessment and a degree of judgment are required in all patients with *apparently* isolated, but significant facial injuries. The decision to allow these patients to sit up is based on a "risk-benefit analysis," *i.e.*, the risks and benefits of keeping the patient supine with potential airway obstruction versus the risks and benefits of axial loading of a *possible* spinal injury.

Combative patients with obvious facial injuries who refuse to lie down may initially require management on their side (following careful log-rolling). This is not the best position to maintain during assessment and management, but it is possible in some patients. This also requires an element of judgment. Although the spine is not formerly immobilised, the main consideration under these circumstances is to do no further harm (which may occur by restraining them). Alternatively some patients may be allowed to sit up (other injuries permitting). However, the head still needs to be supported to minimise movement. If possible a hard collar should be applied.

In those patients who cannot sit up or be logged-rolled, two critical decisions are therefore necessary:

1. Does the airway need securing? (*i.e.*, anaesthesia and intubation) and
2. If so, how urgently?

Not all patients with facial injuries develop airway obstruction. Furthermore, following anaesthesia, loss of contact precludes further clinical evaluation (notably level of consciousness). This often results in the need for urgent CT scanning, which may otherwise have been avoided if the patient was awake and could have been assessed clinically. On the other hand, all supine patients can potentially vomit unexpectedly and therefore need to be kept under close observation.

Fig. 1.7 This patient received a localised blow to the face when the door of a lorry swung round and struck him. He was walking around at the scene with significant facial bleeding, when the paramedics arrived. A good example of "primum non nocere"—if he had been placed supine his airway could have obstructed

Consequently for all supine patients, there should be a clear plan of how to manage vomiting should it suddenly occur. Ideally, a senior experienced anaesthetist, or other clinician trained in advanced emergency airway management, should be present during the assessment of these potentially problematic patients. A "difficult-intubation trolley" should also be readily available in the resuscitation room.

Whatever the circumstances, all efforts should be made to protect the cervical spine as best as possible. This requires the minimum of manual in-line immobilisation, but ideally a

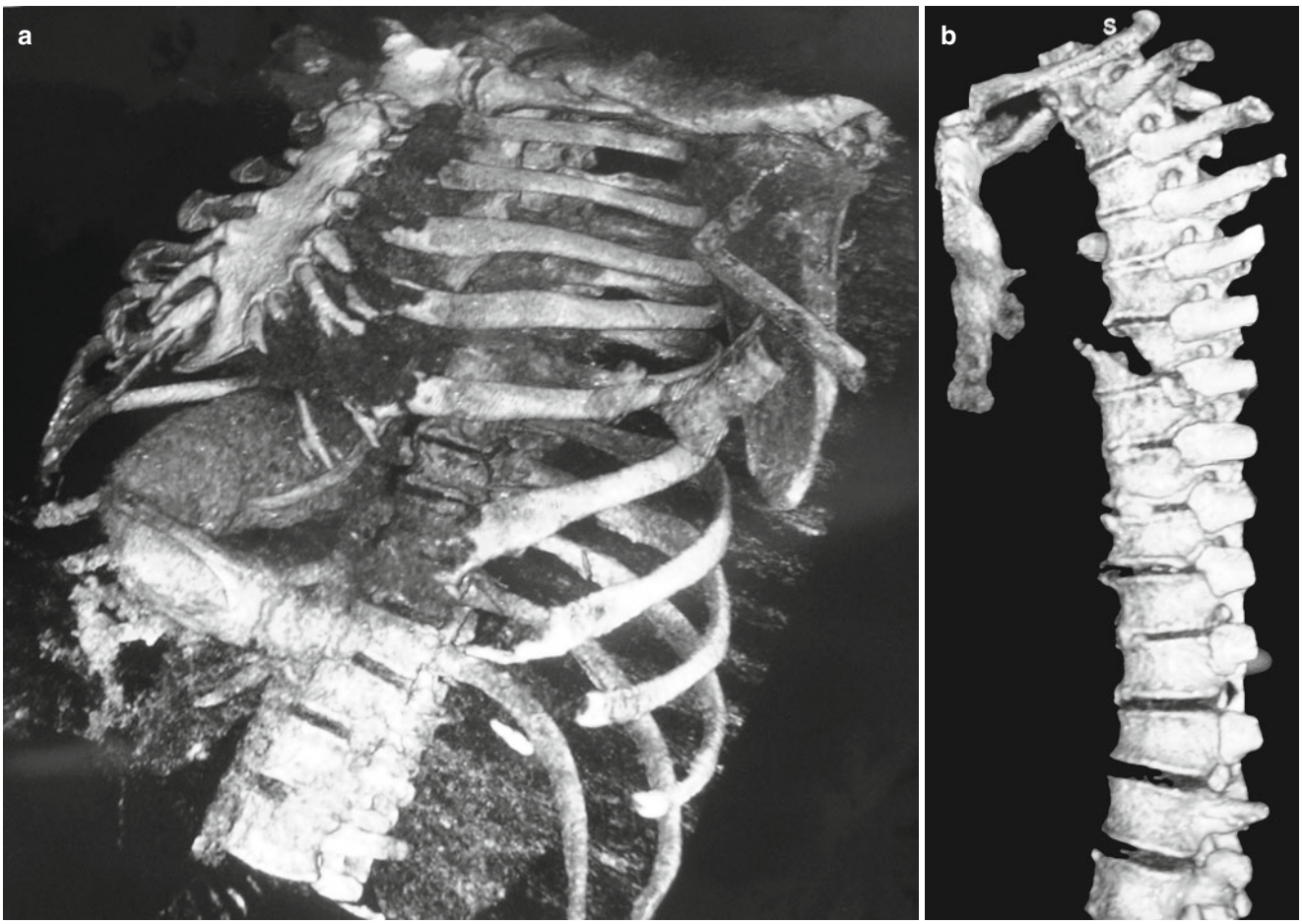

Fig. 1.8 Multiple rib fractures (**a**) and a vertical split in a thoracic vertebra (**b**) following a crush injury. This patient required spinal immobilisation and certainly would not have been able to sit up if coexisting facial injuries were obstructing the airway. This would have required urgent intubation

well-fitting hard collar, blocks and straps should be applied. Hard collars should fit properly, particularly in patients with mandibular fractures. If they do not, the fractures may be displaced further. However, hard collars have also been reported to exacerbate intracranial hypertension in patients with severe head injury. In such cases, other measures to immobilise the neck may be appropriate (the patient will be unconscious and therefore unlikely to move their own head).

Cervical spine injuries need to be "cleared" as soon as possible, particularly if anaesthesia and intubation are required. This can be especially difficult in the presence of alcohol intoxication, brain injury, opiate administration, or distracting facial injuries.

Table 1.8 "Can I sit up?"

Consider the following:
Is the patient just agitated or intoxicated, or is this a sign of partial airway obstruction?
Mechanism of injury: is this an isolated facial injury, or could there be spinal, torso, or pelvic injuries?
Is the airway at risk from an easily treatable cause (foreign body, mobile fracture), or a complex cause? (Impacted midface, active bleeding)
Is the face/airway swollen and if so, is it likely to get worse?
Is there significant, ongoing facial haemorrhage?
Is imaging outside the resuscitation room likely to be required (transfers)?
Is the clinical scenario likely to deteriorate? (swelling/head injury/drugs)
Who is helping me?

1.5.3 The Significance of Facial Fractures and Effects of Soft Tissue Swelling on the Airway

1.5.3.1 Mandible Fractures

Loss of tongue support and significant swelling of the floor of the mouth may occur in patients with bilateral ("bucket handle") or comminuted fractures of the mandible. These tend to follow relatively localised, but high-energy impacts (*see* Figs. 1.9 and 1.10).

In alert patients, self-control of the airway may still be possible, even if they are supine. However, it is not secure and these patients should not be left unattended if they are restrained. In the presence of coexisting head injuries or intoxication, loss of tongue control and other protective reflexes may rapidly become a problem (even if there are no fractures). Comminuted (and therefore high-energy) fractures of the mandible carry a significant risk to the airway, not only from loss of tongue support, but also from significant soft tissue swelling and intraoral bleeding, which commonly occur (*see* Fig. 1.11). Anaesthesia and intubation should therefore be considered early. If this is withheld, the patient's airway must be reassessed frequently. With the more simple (low-energy) anterior fractures, temporarily reduction and stabilisation may be possible by placing a "bridle wire" around the adjacent teeth. This can usually be done under local anaesthesia and is described elsewhere. A bridle wire reduces bleeding from the torn mucosa, and by supporting the fracture enables the patient to swallow more effectively.

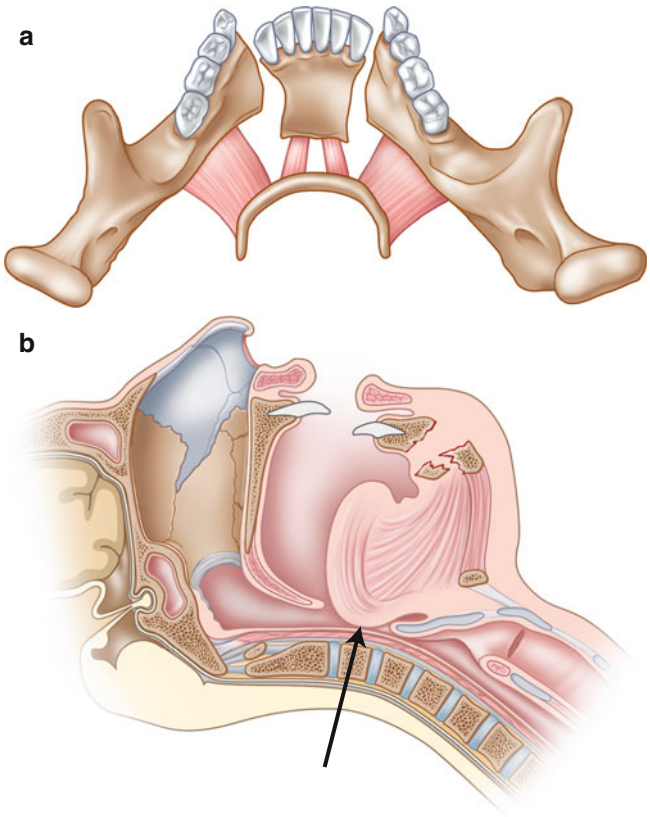

Fig. 1.9 "Bucket handle" or comminuted fractures of the mandible place the airway at risk. The tongue is attached to the central mobile fragment(s) (**a**). If the patient is supine, any displacement can allow the tongue to fall back and obstruct the upper airway (**b**). Snoring is a sign of impending obstruction

1.5.3.2 Midface Fractures

Occasionally, collapsed midface fractures may cause airway obstruction. High-energy impacts to the relatively fragile "middle third" of the face may result in comminution of the bones. These can crumple backwards and downwards along the inclined surface of the relatively thick skull base, resulting in impaction of the soft palate into the pharyngeal space, further swelling, and increasing obstruction. In addition, there is usually significant bleeding, which further contributes to the patient's airway problems (*see* Fig. 1.12).

Functionally the facial skeleton can be regarded as a "crumple zone", due to the presence of its sinuses. In some respects this arrangement can be considered as functioning like an airbag or chassis of a car, absorbing much of the impact energy which would otherwise have been transferred to the driver (brain). Whether this is of evolutionary significance is not known.

1.5.3.3 Combined Fractures

When both midface fractures and mandibular fractures occur at the same time (sometimes referred to as "panfacial" fractures), there is a very high risk of airway compromise. In addition to the problems just mentioned, these injuries often bleed profusely and may soon develop significant swelling. Patients may also have associated brain injury, as these fractures occur following high-energy impacts. These types of injury emphasise the need for regular repeated assessments. Airway obstruction, unexpected vomiting and hypovolaemia from unrecognised bleeding are all common consequences, none of which may be read-

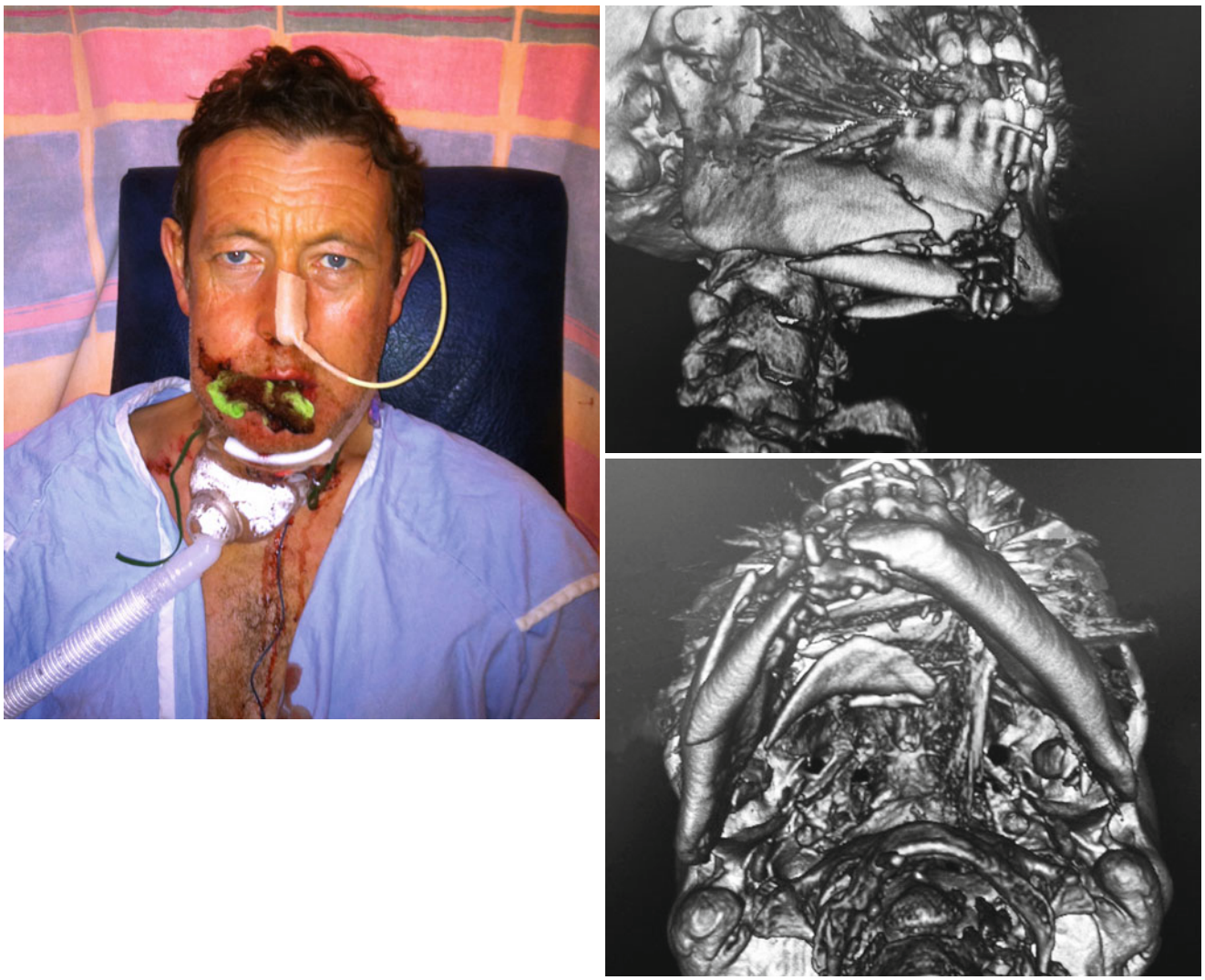

Fig. 1.10 This patient was kicked in the face by a horse, sustaining comminuted fractures of the mandible. He developed airway-threatening swelling over the next few hours, which required urgent intubation and placement of a temporary (percutaneous) tracheostomy, prior to repair

ily apparent or expected on initial presentation. Significant soft tissue swelling inevitably occurs following such high-energy injuries and often necessitates prolonged intubation or planned elective tracheostomy. The role of steroids in the acute management of facial trauma has not been established and their use may be contraindicated in the presence of brain injury.

Usually it is the mechanism of injury, not the fracture pattern, that is most reliable in predicting swelling (*see* Figs. 1.13 and 1.14).

Significant swelling can occur in patients with relatively minor "cracks" of the facial skeleton. It can also occur in the absence of fractures—notably in patients taking anticoagulants, those with clotting abnormalities, and the elderly. Swelling can take several hours to occur. Clinicians therefore need to be wary and regularly re-examine the patient. Stridor is a particularly worrying sign and often requires urgent intubation.

Retropharyngeal haematoma may indicate an underlying cervical spine fracture as well as result in airway obstruction. Fractures of the hyoid bone (seen on the lateral cervical spine film) should be regarded as a "marker" of significant injury, indicating risks of obstruction.

Fig. 1.11 Resolving sublingual haematoma 1 week following mandibular fracture. Patient was on warfarin (International Normalized Ratio [INR] 6 on presentation) with partial airway obstruction. Management included urgent fiberoptic intubation, correction of INR, incision and drainage of haematoma and repair of fracture

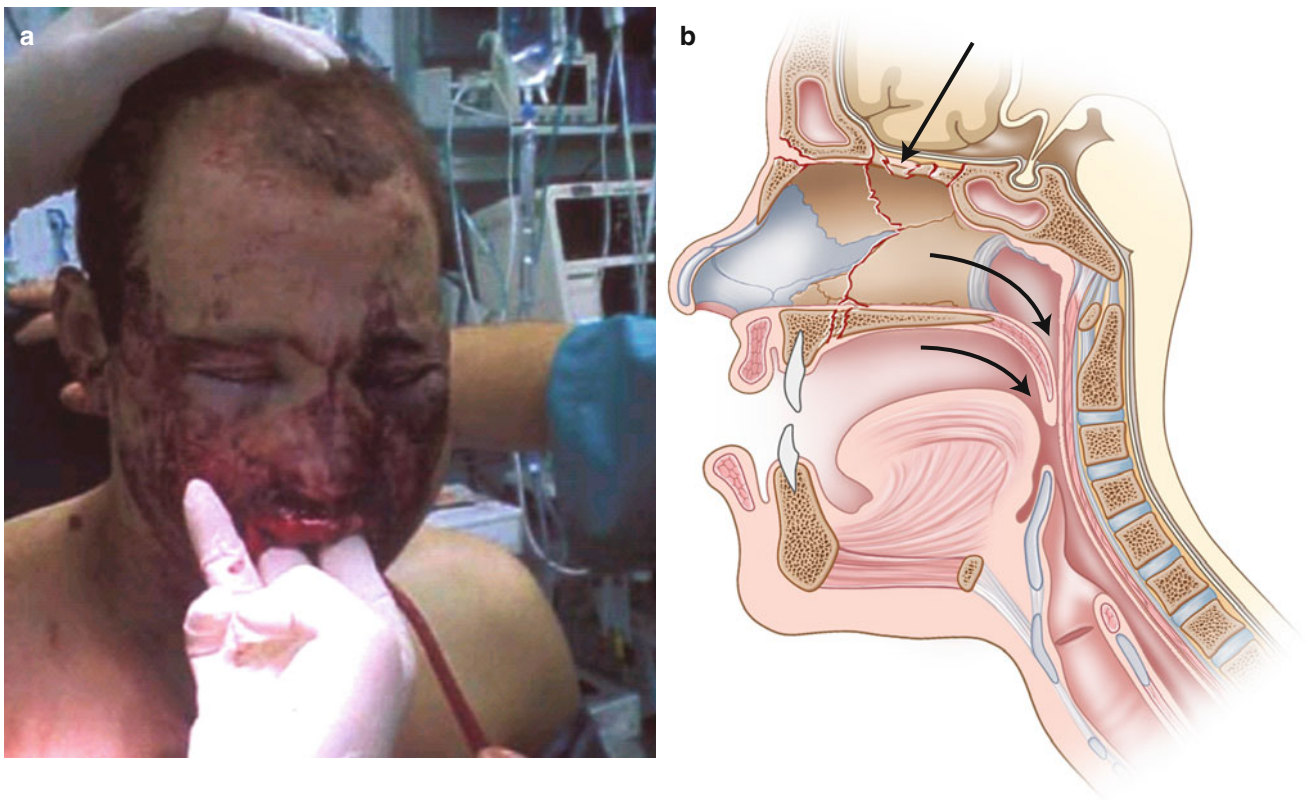

Fig. 1.12 This patient had severe midface fractures that were very mobile (**a**). Collapse of the soft palate together with swelling can result in airway obstruction (**b**). The patient was found at the scene of injury protecting his own airway by leaning forward. The maxilla is being gently repositioned to maintain the airway and control haemorrhage. This patient required urgent intubation to enable full control of the haemorrhage and protect the airway from progressive swelling (already evident)

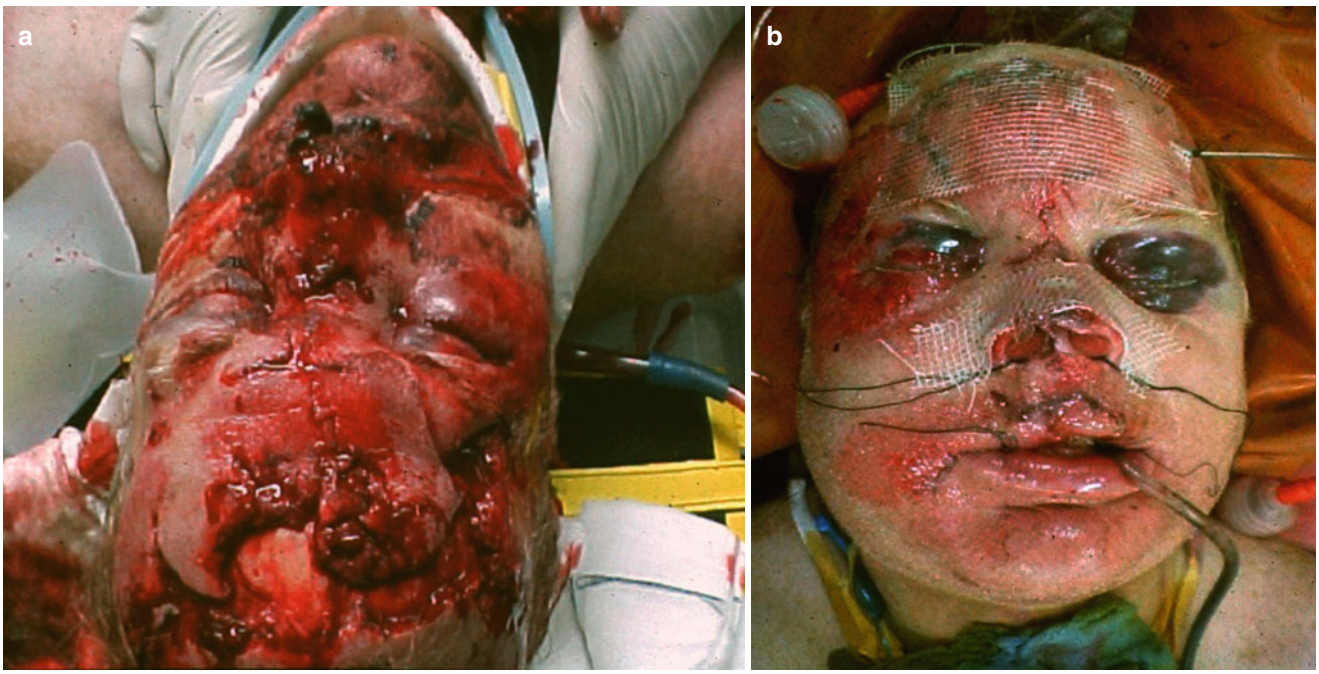

Fig. 1.13 These two views are of the same patient initially on arrival in the emergency department (**a**) and 24 h later (**b**). There has been a huge amount of swelling overnight. This was anticipated in view of the mechanism of injury. The patient was intubated in the emergency department and a tracheostomy performed after further assessment of all injuries

Fig. 1.14 Progressive facial swelling following isolated midface fractures. The mandible is intact. This patient is being nursed on her side but will require very close observation for the next 24 h

1.5.4 The Anterior Neck

This anatomical site can be easily overlooked during initial assessment (particularly when the patient has a hard collar on), but requires careful and regular examination. If the patient arrives with a collar on and an injury here is suspected, the collar should be unfastened and the anterior neck examined, while an assistant maintains in-line manual immobilisation. The anterior neck can be regarded as a watershed between "Airway" and "Breathing"—life-threatening problems in both (and occasionally "circulation") can manifest clinical signs here (*see* Table 1.9).

Injuries to the larynx can quickly swell and result in airway obstruction. A hoarse voice, haemoptysis, surgical emphysema, and fracture crepitus in the neck are highly suggestive of a serious injury and should be actively looked for. Motorcycle helmet wear, strangulation, and contact sports are important clues from the history. It is important to carefully palpate the great vessels, hyoid, and larynx for signs of injury and to look for external swelling (which may reflect internal swelling). Surgical emphysema and distended neck veins may also indicate a thoracic problem that needs to be urgently evaluated (*see* Fig. 1.15).

Table 1.9 Useful clinical signs in the anterior neck

Tracheal deviation or separation
Laryngeal tenderness or crepitus
Hyoid tenderness
Surgical emphysema
Distended neck veins
Open wounds
Significant swelling

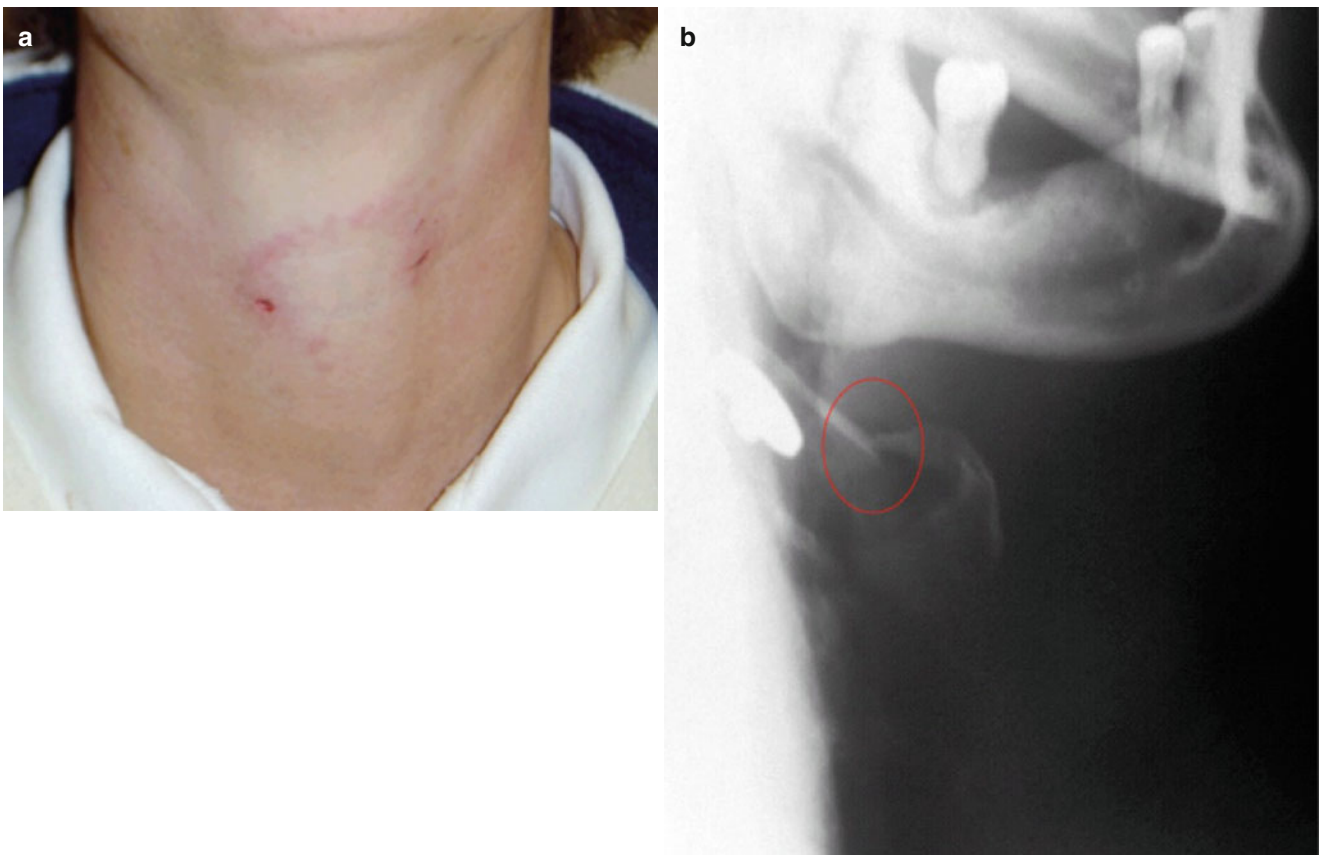

Fig. 1.15 The anterior neck is often overlooked in the initial assessment of the multiply injured patient. In this case it was not. The patient was bitten in the neck by a dog (**a**). There is a fracture of the hyoid bone, as shown in the radiograph (**b**)

1.6 Airway Management in Facial Trauma

1.6.1 Initial Measures

All trauma patients should receive oxygen. In supine patients, the risk of obstruction should always be anticipated. The ability to maintain the patient's own airway may become increasingly difficult and can suddenly be lost. Whether or not this occurs depends on several factors (notably the severity of the facial injuries), but once the airway has been lost it can be very difficult to rapidly secure it. With severe injuries there may be mobile, bleeding fractures, and swelling can develop quickly. Early assistance from an experienced anaesthetist is therefore essential. Occasionally, a surgical airway may be required. This is more likely when there is gross swelling from extensive injuries, or an inability to intubate the patient. Members of the trauma team should therefore be competent in performing this procedure if it is urgently required. So should facial surgeons.

Several well-known techniques exist for initially maintaining an airway (*see* Table 1.10).

It is important to appreciate that maintaining an airway is not the same as securing it. Patency can still be lost. High-volume suction (using a wide bore, soft plastic sucker) should always be readily available to clear the airway of blood and secretions, taking care not to induce vomiting. Any loss of the gag reflex during suctioning should prompt consideration of the need for early endotracheal intubation.

Table 1.10 Airway maintenance techniques in trauma

Suction
Jaw thrust (keeping head in neutral position)
Chin lift (keeping head in neutral position)
Oro- and nasopharyngeal airways
Tongue suture
Laryngeal mask

The jaw thrust and chin lift are commonly used techniques, but these may be difficult to do (although not impossible) when there are multiple fractures of the mandible. Care must also be taken not to distract any fractures as this is not only painful, but results in further swelling and blood loss, and can tear mucosa (*see* Fig. 1.16).

In trauma, the chin lift is a two-person technique. The head is not extended into the "sniffing position" as it would normally be (remember the cervical spine). An assistant is therefore required to support the head. Even with such support (and a hard collar) both the chin lift and jaw thrust have been shown to produce a small amount of movement of the cervical spine. They must therefore be performed very carefully.

If the patient is unconscious and has severe injuries with complete loss of tongue support, a tongue suture or pointed towel clip may facilitate suctioning and intubation. Remember that this technique itself may cause bleeding (*see* Fig. 1.17).

If the midface has been impacted posteriorly, it may need to be repositioned to improve the airway. Grasping the premaxilla and gently pulling it forward achieves this. The movement does not require much force, but is often uncomfortable for the patient. It must also be undertaken with protection of the cervical spine. Sometimes the maxilla hangs loose and needs to be gently lifted. Repositioning the maxilla not only improves the airway but reduces blood loss (*see* Fig. 1.18).

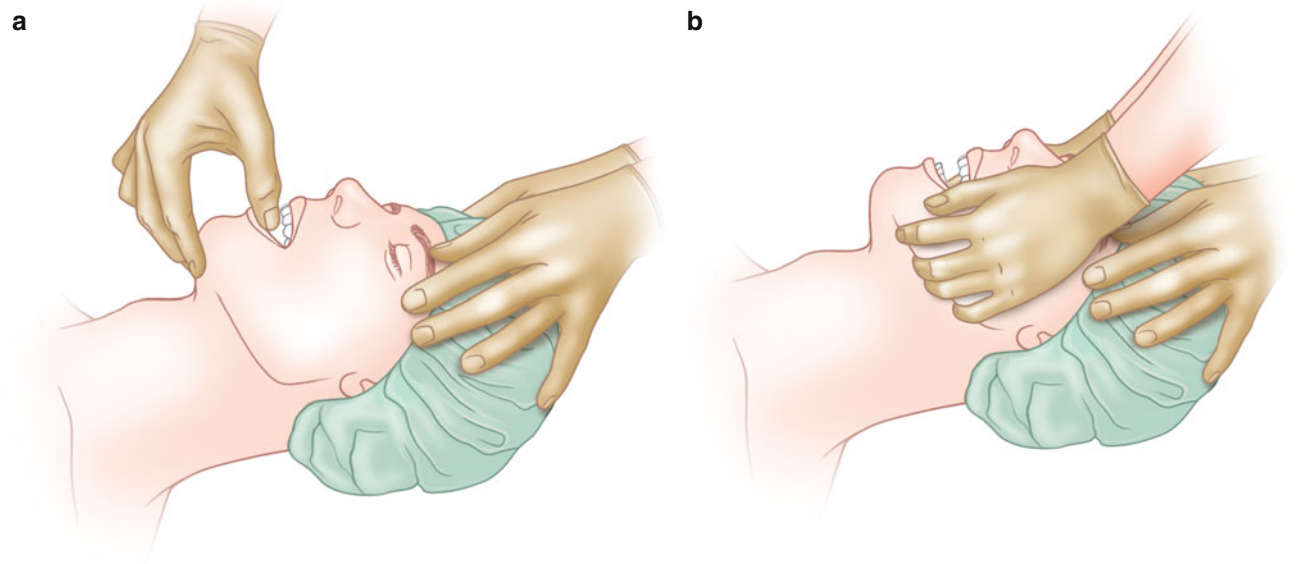

Fig. 1.16 In trauma, both the chin lift (**a**) and jaw thrust (**b**) are performed with the head supported in the neutral position (to protect the cervical spine). The "sniffing position" is therefore contraindicated

Fig. 1.17 Use of a tongue suture to facilitate intubation. A large deep tongue laceration is also being rapidly closed. Bleeding from it was preventing a clear view of the vocal cords

Once reduced, it may be necessary to provide support with a mouth prop (if the patient has an intact lower jaw).

1.6.2 Airway Maintenance Devices

A number of devices to maintain an airway are currently available, but the use of some of these in trauma (especially facial) is controversial. The laryngeal mask airway (LMA) has found widespread use in elective anaesthesia. Although it is cuffed to help maintain its position, in terms of airway protection it should be regarded as little more than an oropharyngeal airway. Use of the LMA requires specific training and it is not without complications (*i.e.*, it can induce vomiting and placement can produce movement of the neck). Oropharyngeal and nasopharyngeal airways are also commonly used in airway maintenance. However, nasopharyngeal tubes are generally regarded as contraindicated in the presence of midface or craniofacial trauma.

Fig. 1.18 Temporary reduction of midface fractures to control haemorrhage (**a**, **b**)