OHST OXFORD HIGHER SPECIALTY TRAINING

TRAUMA FOR THE FRCS (Tr + Orth) EXAMINATION

Edited by
Alex Trompeter | David Elliott

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FOREWORD

Trauma makes up half of the workload of the average consultant in trauma and orthopaedics and is a core component of the training curriculum in the United Kingdom. Competency in trauma management requires excellent judgement and good decisions: the majority of musculoskeletal trauma requires skilful, non-operative treatment, and so good decision-making is just as important as surgical skill in trauma management. The FRCS (Tr + Orth) examination includes a large trauma component and the candidate's decision-making will be tested in both written and oral examinations.

There are many excellent titles on trauma, but none that focus on the key questions the examiner is likely to ask. This title fills that void and will serve as a great revision aid and rehearsal for the examination. In addition, it will also be a very useful educational tool for decision-making. I am certain that many registrars will find it invaluable to quickly review *Trauma for the FRCS (Tr + Orth) Examination* before presenting a case at the morning trauma conference (and then facing the inevitable questions from the boss).

Chris Moran
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PREFACE

The Intercollegiate Fellowship of the Royal College of Surgeons (FRCS) exam in Trauma and Orthopaedics (Tr + Orth) is one of the last hurdles to cross in the progression from registrar to consultant. This exam has always been held in high regard and is rightfully respected. Despite its reputation as being tough and full of mysterious cases, it is actually a very fair assessment of a trainee's ability and his or her likelihood of coping as a new consultant. The curriculum for the exam is huge and includes a significant focus on orthopaedic trauma. It is reasonable therefore to expect to have your knowledge of orthopaedic trauma surgery tested in both the written and oral parts of the exam. Trauma topics can not only appear in the dedicated trauma viva, but also in the basic sciences, paediatric, hand, and adult pathology viva tables, as well as in the clinical cases. Trauma topics could quite easily represent a third of the questions in the exam as a whole.

Many trainees mistakenly assume that because they have been exposed to trauma throughout their training they have a thorough understanding of the topic. Unfortunately, for a simple long bone nailing, for example, or something else one has performed many times, it is perhaps harder to explain in detail the biomechanics and evidence base around the topic in the pressure situation of a viva. It is for this reason that many people come unstuck in the exam, and exactly why this text has been compiled. For too long, trauma topics have been relegated to a chapter or two in books for the FRCS exam as a whole—we hope that this book will allow candidates to revise, understand, and discuss orthopaedic trauma to the level required.

Orthopaedic trauma surgery is fast becoming a recognized subspeciality in its own right. It is clear that, much like arthroplasty, foot and ankle surgery, spinal surgery, and so forth, trainees who have an interest in that field will excel at the exam and throughout their career in that topic. This book is predominantly aimed at providing trainees with the knowledge, technique, and evidence base to pass the trauma component of the FRCS exam. For trainees with an interest in a trauma career this title will polish your knowledge and viva skills, and for those who see trauma as a burden it will help you gain and organize the basic understanding required to get you through the exam. Furthermore, for those who choose not to pursue careers as dedicated trauma surgeons yet still are required to cover the on-call rota in their consultant appointment, this book should give a sound foundation in and understanding of orthopaedic trauma.

We hope you find it useful.

Alex Trompeter
David Elliott

ACKNOWLEDGEMENTS

There is no doubt that this book could not have been produced without the help of many amazing people. All the people who contributed questions are the real authors, and in an ideal world they should all have their names on the front cover! For putting up with so many emails and nagging messages and still coming up with such excellent material, I am truly grateful to you. Without you there would be no book. Thanks also to the publishers, Oxford University Press, for taking all this material and turning it into a reality. You have been very patient with me and your guidance along the way has been invaluable.

Perhaps the biggest thank-you ought to go to my wife, Kirsty, and children, Oscar and Eve, who have sat by and watched me spend many an evening toiling away. For those moments when it seemed all was lost as the computer crashed (again) to the points where I was searching in desperation for yet another image to use in a viva, you kept me sane and made me remember the reasons behind all of this. As always, you make it all worthwhile.

Alex Trompeter

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ABBREVIATIONS

A&E	accident and emergency
ACDF	anterior cervical discectomy and fusion
ACE	angiotensin-converting enzyme
ACJ	acromioclavicular joint
ACL	anterior cruciate ligament
AIN	anterior interosseous nerve
AIS	Abbreviated Injury Scale
AISmax	Maximum Abbreviated Injury Score
ASIS	anterior superior iliac spine
ATLS	Advanced Trauma Life Support
AVN	avascular necrosis
BMI	body mass index
BMP	bone morphogenetic protein
BOAST	British Orthopaedic Association Standards for Trauma
CABG	coronary artery bypass graft
COPD	chronic obstructive pulmonary disease
CPN	common peroneal nerve
CPP	cerebral perfusion pressure
CRPS	complex regional pain syndrome
CSF	cerebrospinal fluid
CT	computed tomography
DHS	dynamic hip screw
DISH	diffuse idiopathic skeletal hyperostosis
DISI	dorsal intercalated segment instability
DPN	deep peroneal nerve
DRUJ	distal radioulnar joint
ECRB	extensor carpi radialis brevis
ECU	extensor carpi ulnaris
EDB	extensor digitorum brevis
EDC	extensor digitorum communis
EDL	extensor digitorum longus
EHL	extensor hallucis longus

EPL	extensor pollicis longus
ESR	erythrocyte sedimentation rate
FCR	flexor carpi radialis
FCU	flexor carpi ulnaris
FHL	flexor hallucis longus
FPL	flexor pollicis longus
FSH	follicle-stimulating hormone
GCS	Glasgow Coma Scale
GDF	growth differentiation factor
GT	greater trochanter
HIT	heparin-induced thrombocytopenia
ICP	intracranial pressure
IL	interleukin
IM	intramedullary
ISS	Injury Severity Score
ITB	iliotibial band
LEAP	Lower Extremity Assessment Project
LOS	length of hospital stay
LSV	long saphenous vein
MAP	mean arterial blood pressure
MC	metacarpal
MCFA	medial circumflex femoral artery
MCL	medial collateral ligament
MCP(J)	metacarpophalangeal (joint)
M-CSF	macrophage colony-stimulating factor
MIPO	minimally invasive plate osteosynthesis
MISS	Modified Injury Severity Score
MOF	multiple organ failure
MRI	magnetic resonance imaging
MSC	mesenchymal stem cell
MT	metatarsal
NASCIS	National Acute Spinal Cord Injury Study
NICE	National Institute of Health and Care Excellence
NV	neurovascular
NVB	neurovascular bundle
Occ	occiput
OECs	olfactory ensheathing cells
ORIF	open reduction and internal fixation
PCL	posterior cruciate ligament
PDGF	platelet-derived growth factor

PER	pronation–external rotation
PET	positron emission tomography
PIN	posterior interosseous nerve
PIP(J)	proximal interphalangeal (joint)
PITFL	posterior inferior tibiofibular ligament
PLC	posterior ligamentous complex
RLN	recurrent laryngeal nerve
RTA	road traffic accident
SCJ	sternoclavicular joint
SER	supination–external rotation
SNAC	scaphoid non-union advanced collapse
SPN	superficial peroneal nerve
SSSC	superior shoulder suspensory complex
STASCIS	Surgical Treatment of Acute Spinal Cord Injury Study
TAD	tip to apex distance
TFCC	triangular fibrocartilage complex
TFL	tensor fascia latae
THR	total hip replacement
TKR	total knee replacement
TMT	tarsometatarsal
TLSO	thoracolumbosacral orthosis
VEGF	vascular endothelial growth factor
VTE	venous thromboembolism
WHO	World Health Organization

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INTRODUCTION

The FRCS (Tr + Orth) exam and the scoring system

The Intercollegiate FRCS (Tr + Orth) exam is the last exam that most orthopaedic registrars will take in their progression toward the consultant grade. It is a fair but tough assessment of the curriculum set out by the Joint Committee on Surgical Training (JCST) and Specialist Advisory Committees (SAC), and now governed by the Intercollegiate Surgical Curriculum Project (ISCP).

The JCST is an advisory body to the four surgical royal colleges and surgical speciality associations of the UK and Ireland for all matters relating to surgical training. It is the parent body for the ISCP. The JCST enrols surgical trainees, monitors their progress, and makes recommendations to the regulator when they are ready for the Certificate of Completion of Training (CCT). The FRCS exam makes up one vital component of the award of the CCT.

This book is designed around the curriculum and exam in its current state (as of 2013–15). It is advised that any trainee applying to sit the exam is familiar with the curriculum and the exam structure. As this may change, one should familiarize oneself with the JSCT and ISCP websites, as well as information from the Intercollegiate exam website. Of course, all of this can, and does, change. Indeed the governing bodies may now be different from those above, which were correct at the time of writing.

Currently the FRCS (Tr + Orth) exam is divided into a written section, comprising single best answers (SBAs) and extended matching questions (EMQs) over two 3-hour papers sat on a single day. These questions are now set electronically and candidates are able to take these papers at local testing centres. There is no negative marking so all questions should be attempted. Ten to twelve questions will be based on interpretation of a scientific paper only seen on the day. Approximately 245 questions will cover the whole syllabus over the two papers. The pass mark is adjusted according to the scores from all candidates sitting that specific exam—it usually sits around 65%.

Assuming success, most candidates progress to Part 2 about 3 or 4 months later. Part 2 is made up of both viva and clinical exams, taken over 2–3 days at various hospitals, hotels, and conference facilities around the country.

The marking system for the viva and clinical exams historically uses a scale from 4 to 8. A mark of 4 represents an outright fail for that station, while 8 is an excellent pass. A score of 6 is considered a pass for that station. Getting a 4 does not mean an automatic fail of the whole exam, but will require you to make up the marks elsewhere. There are 96 'marking opportunities' over the whole viva/clinical—48 in each section. In fact, two of these marking opportunities are awarded at each point, one by each examiner, so there are only 48 topics in the whole viva/clinical. Ninety-six marking opportunities means 768 marks is the maximum, with 576 (96 × 6) being the overall pass mark.

The viva tables (trauma, adult pathology, basic science, paediatrics/hands) account for 12 marking opportunities each (48 in total). One table will cover six topics, three from each examiner, each being topic marked twice; therefore there are 12 marking opportunities. The clinicals account for the other 48 marking opportunities—12 for each station (two short case stations, two

intermediate). It is recommended that you check the latest method/breakdown of scoring prior to the exam as this can (and does) change!

Approach to revision and the work required

The sheer volume of work required for the exam makes for a daunting prospect at the start of your revision programme. Most people allow somewhere between 9 and 12 months for the whole process. It takes a month or two to build up to meaningful levels of work, and this time is typically spent procrastinating by buying books, booking courses, and designing the revision timetable! Five to 6 months of reading is required for the written paper, with another 3–4 months dedicated to the viva/clinical thereafter.

A lot of money can be spent on courses, and some are better than others. The same goes for textbooks. Remember, the revision-style textbooks are likely to be easier to work through than all four volumes of a major orthopaedic reference text! This book fills the gaps left by others—there is not a single book currently that focuses on trauma for the FRCS (Tr + Orth), whilst there are dedicated books for basic sciences, the clinical, hand surgery, paediatrics, and so forth.

Many people get very hung up on the need to know all the latest evidence and research for the exam. This is useful only if you have done so well in the viva or clinical that you actually get asked about a paper you may have read to score 8 points! It is much better to have the basics sorted, then rely on guidelines (British Orthopaedic Association, National Institute for Health and Care Excellence, etc.) and Cochrane summary reviews as support for your answers. While this title is evidence based, and references are provided for each topic, the focus for the exam should above all else be on the principles and concepts.

The hardest part of revision is the juggling act between the day job as a registrar, family life, revision, and the necessary breaks. Social activities tend to be put on hold, and weekday TV watching in the evening is one of the first things to go! But do not forget how important it is to step away from the books at times. Some candidates feel happiest working in groups, others prefer to fly solo. There is no substitute for practising viva technique out loud, and demonstrating examination skills, but any sessions spent with others need to be productive. I personally favoured asking consultants and senior registrars who have passed the exam to give viva sessions, as opposed to the more gentle chats you have with other candidates.

Overall a good 10–20 hours revision per week is required on top of your normal working week. This can easily be achieved with good use of a research session, and a weekend morning—together allowing for up to 12 hours' work. If this is done, only one or two evenings a week are necessary. It is hard to do any work when on call, and you should assume none will get done. Use the morning trauma meetings to your advantage—ask for a viva on every case. If you can stand up to a viva in front of your colleagues you can cope with the stress in the exam hall.

Exam days

For all exams, you should take the time to familiarize yourself with the location and information regarding the process through the day(s). It is helpful to find out that there is no parking available on the morning of the exam! For the clinical and viva you must be smartly presented—this is a test of your competency as a new consultant and that starts with your appearance. Understandably the stress and anxiety will peak as the exam approaches. Whilst there is no method that works for everyone, most people would advise trying to sleep well the night before, avoiding alcohol, and to set an alarm early enough to allow you to have a proper breakfast without rushing!

The written exams now take place at dedicated testing centres. These are utilized by all sorts of companies, including the DVLA, so you may find yourself sitting next to a teenager doing their

driving theory test! This is beneficial in as much as you can often take the exam very close to home, but it is well worth turning up early and asking for a computer in a quiet corner, away from others.

For the Vivas and clinical you may well need to stay in a hotel. It is worth finding out where the examiners are staying and booking a different hotel. Sitting for breakfast opposite the examiner who gave you a tough time in the clinical the day before will make for an awkward situation!

The vivas and clinical involve quite a lot of waiting around. You may have up to 90 minutes between some tables. It is important to remain relaxed during this time. Certainly there is no point in fretting over the station you have just had, as nothing can be done to change it. It is also best to avoid the groups of people who have books in their hands and seem to be discussing some topic you have never heard of—it will just make you more stressed! Stay calm, read the newspaper, or gloss over a revision card covering a topic you know well to make you feel more at ease. As you are called to the next station, dry your hands, walk forward, smile, and begin . . .

When you sit at the viva table, you should sit confidently, upright, with your hands on the table. Do not cross your arms or slouch. Most examiners will offer to shake your hand as you sit down, let them do this. If they do not offer their hand it is best to just sit down. Smile at them—they will be bored, and if you come across as pleasant and confident, they will be more relaxed. As soon as you sit down, the questions will begin. Listen extremely carefully to every question you are asked. Pause for a second and digest what you have heard. The examiner will usually ask a very specific question; thus if you answer a different question you will start to experience difficulty. Most people struggle because of technique, not a lack of knowledge. If you have an opportunity to draw, you should do so—pictures tell a thousand words. You should, however, speak as you draw—it adds to your point scoring more quickly, and draw big so both examiners can see. If you are shown pictures on a screen do *not* touch the images, just use descriptive terminology.

The favoured approach to a viva is to start simply and give an overview statement. Imagine your answer as like a tree—describe the trunk and major branches before you follow the path down to the finer detail of each leaf. Once the main branches have been described, the examiner will probably guide you to which leaf they want you to talk about. This way you have already picked up marks. If you go straight to one leaf you may end up talking about something you know little about, or indeed is not the topic the examiner wanted to discuss. A good example is bone grafts: it is much better to start by say they can be structural or biological, or they can be classified as autograft, allograft, or xenograft. If you start by talking about beta-tricalcium phosphate or coralline substitutes you will run out of things to say pretty quickly! The caveat to this is that if something is obvious, you should be confident and say it outright: i.e. 'This is a radiograph of an anterior shoulder dislocation because . . . (then describe the features) and I would confirm this with an orthogonal view', rather than 'This is an AP radiograph of a shoulder joint. The glenoid and humeral head seem overlapped, but I cannot identify any fractures. It could be that this is a shoulder dislocation but I would need to see more images.'

As the viva progresses the questions will evolve. Either because you are doing well or you are going off track. A tricky question may be one designed to push and challenge you, so do not be worried. If you are being asked about evidence or literature to support your answer it will usually imply you are pushing for a mark of 7 or 8. If you do not know an answer, say so—do not make things up—get back to something to talk about that will pick up marks. If you seem to be going down a path you did not want to take, pause, and offer to either start again, or suggest an alternative. When the time is up, or if you have run out of things to be asked about, the examiner will suggest you move on, and the next topic begins.

The layout of the book

This book shall attempt to cover the main aspects of the exam in relation to trauma. There are sections of SBAs, EMQs, and vivas, with questions and answers separated as well as an anatomy

section in Chapter 17. Almost all acute trauma topics are touched upon in at least one section. Most answers are supported by discussion or evidence, if appropriate, for those who want more. The question format reflects that of the exam in its current state.

The SBAs and EMQs have been organized into sections with common themes. The questions and answers are separate to allow you to test yourself. The vivas have their answers and discussion directly after each individual question to allow someone else to viva you with ease; they are again organized into common themed sections.

Single best answer questions (SBAs)

SBAs have a statement or question followed by five possible answers. Only one correct answer is possible from the five options. There is no negative marking so it is worth a guess if you genuinely do not know the answer. It is vital that you read the questions and answer stems very carefully—double negatives are common and can easily trick you.

Extended matching questions (EMQs)

EMQs in this book start by offering the list of possible answers. Then there is a principal statement or question that sets the direction for the specific questions that follow. There are three or four specific questions or statements for each main stem that require you to choose an appropriate 'answer' from the preceding list. Each answer can be used once, more than once, or not at all.

Anatomy and approaches

The book includes a summary chapter (Chapter 17) covering anatomy approaches—these come up frequently in the exam. There is a set 'patter' for description of a surgical approach in the viva, which is described in this chapter. While it is not the only way it does allow you to sound confident when describing an approach you have never performed.

Vivas

The viva section will cover most trauma topics. This book is not meant to be an exhaustive text or a complete revision aid, but rather it demonstrates examples of answers to common topics, with the focus on the structure and delivery of the salient points. Each viva starts with a prompt, as in the real exam. This is usually a radiograph, clinical photograph, or implant. It allows the scene to be set and an easy opening question to be asked. The questions and answers are again separated, and the questions have been designed to progress through the marking scheme from 4–8. Discussion and evidence for most questions are provided if appropriate.

There is no clinical section to this book. It stands to reason that trauma cases can appear in both the short and intermediate clinical cases, but normally these will be post-traumatic complications or sequalae. It would be well worth being confident in describing deformities, fixators, scars, etc. but the approach to the patient here should be the same as for the elective situation.

Finally, this book is written to help you pass the FRCS (Tr + Orth) and it will no doubt require some changes and updates to the second edition and beyond—especially as evidence or guidance changes and evolves, but also if there are (unintentional and very rare!) errors in the text. This is not intended to be an instructional text, but rather a platform for you to build and work from, giving you structure to your answers. It is not always possible to include every change in guidance and evidence as much of the text is written well in advance of publication. If you pass the exam and feel you would like to be a contributor to future editions, please do get in touch through the publishers.

Good luck!

Part 1 **Single Best Answers**

chapter
1

BASIC SCIENCE OF ORTHOPAEDIC TRAUMA

Questions

1. Which of the following is not a pre-requisite for the contact healing variant of primary bone healing?

Select the single most appropriate answer.

A. Absolute stability
B. Anatomical reduction
C. An ultra-low-strain environment
D. Formation of granulation tissue
E. Interfragmentary compression

2. Which phase of secondary bone healing most closely approximates the direct laying down of lamellar bone seen in primary bone healing?

Select the single most appropriate answer.

A. Haematoma formation
B. Hard callus
C. Inflammation
D. Remodelling
E. Soft callus

3. Which of the following is true of the cutting cones that characterize the contact healing variant of primary bone healing?

Select the single most appropriate answer.

A. Osteoblasts precede osteoclasts
B. They form bridging osteons that mature into lamellar bone by direct remodelling
C. They occur where strain is less than 10% and the gap between bone ends is less than 1 mm
D. They produce longitudinal cavities at a rate of 500 μm/day
E. They result in sequential generation of a bony union and the restoration of Haversian systems

4. Which of the following is not true of the gap-healing variant of primary bone healing?

Select the single most appropriate answer.

A. A second remodelling resembling contact healing occurs
B. Lamellar bone is formed over 3–8 weeks
C. Lamellar bone is formed perpendicular to the long axis
D. Simultaneous generation of a bony union and the restoration of Haversian systems
E. The fracture gap must not exceed 1 mm

5. Which strain environment is required for primary bone healing?

Select the single most appropriate answer.

A. Over 100%
B. Up to 100%
C. Up to 17%
D. 2–10%
E. Less than 2%

6. Which type of callus allows pluripotent cells to differentiate into osteoprogenitor cells which produce bone directly?

Select the single most appropriate answer.

A. Endosteal callus
B. Exosteal callus
C. Medullary callus
D. Periosteal callus
E. Soft callus

7. Which of the following is not a member of the transforming growth factor beta (TGF-β) superfamily?

Select the single most appropriate answer.

A. Activin
B. BMP4 (bone morphogenetic protein 4)
C. GDF2 (growth differentiation factor 2)
D. IL-1 (interleukin 1)
E. TGF-β1

8. What strain environment is required for the formation of the calcified fibrocartilage found in soft callus?

Select the single most appropriate answer.

A. Over 100%
B. 20–100%
C. 10–20%
D. 2–10%
E. Less than 2%

9. Which of the following statements is incorrect regarding indirect (secondary) fracture healing?

Select the single most appropriate answer.

A. Angiopoetin-12 is a regulator of vascular regeneration and neoangiogenesis
B. Generation of callus depends on the recruitment and differentiation of mesenchymal stem cells mobilized from local soft tissues, cortex, periosteum, and bone marrow
C. Generation of callus depends on the recruitment and differentiation of mesenchymal stem cells mobilized from remote haemopoietic sites
D. Indirect fracture healing involves both intramembranous and endochondral ossification
E. Osteoblasts express high levels of vascular endothelial growth factor (VEGF), which promotes the invasion of blood vessels

10. Which of the following does not occur during the mineralization and resorption of cartilaginous callus?

Select the single most appropriate answer.

A. Chondrocytes become hypertrophic
B. Mesenchymal stem cells differentiate into osteoblastic lineage
C. Mineralized cartilage is resorbed
D. Osteoclast apoptosis
E. The extracellular matrix is calcified

11. The correct sequence of steps for a small fragment 'lag' (interfragmentary compression) screw is as follows.

Select the single most appropriate answer.

A. Reduce fracture anatomically, 3.5 mm drill for pilot hole, 2.5 mm drill for gliding hole, countersink, measure, tap, screw
B. Reduce fracture anatomically, 3.5 mm drill for gliding hole, 2.5 mm drill for pilot hole, countersink, measure, tap, screw
C. Reduce fracture anatomically, 2.5 mm drill for pilot hole, 3.5 mm drill for gliding hole countersink, measure, tap, screw
D. Reduce fracture anatomically, 3.5 mm drill for gliding hole, 2.5 mm drill for pilot hole, countersink, tap, measure, screw
E. Reduce fracture anatomically, 3.5 mm drill for gliding hole, 2.5 mm drill for pilot hole, measure, tap, countersink, screw

12. Which of the following is not true regarding locked screws?

Select the single most appropriate answer.

A. The working length of a monocortical locked screw is the amount of screw in contact with the cortex
B. The working length of a monocortical locked screw is the distance between the undersurface of the plate and the bone
C. The working length of a monocortical locked screw is shorter in osteoporotic bone
D. The working length of a monocortical locked screw is not dependent on the distance of the plate from the bone, nor the diameter of the screw
E. The working length of a monocortical locked screw is independent of the number of screws and is the same for self-tapped and self-drilling and tapping screws

13. When comparing the screws used for a locking plate with those used with conventional plates which of the following best describes the differences?

Select the single most appropriate answer.

A. The locking screws have a relatively smaller core diameter
B. The locking screws have a relatively greater core diameter
C. The locking screws have a greater difference between the core diameter and the inner diameter
D. The locking screws have a greater pitch
E. The locking screws need to be made from more flexible material

14. Comparing a solid 9 mm intramedullary (IM) nail with a hollow IM nail of the same material with 9 mm outer diameter and 6 mm inner diameter, the hollow nail is:

Select the single most appropriate answer.

A. Less stiff in proportion to the fourth power of the inner radius
B. Less stiff in proportion to the third power of the inner radius
C. Less strong in proportion to the fourth power of the outer radius
D. Stiffer in proportion to the fourth power of the inner radius
E. Stronger in proportion to the fourth power of the inner radius

15. With regard to wound healing following amputation, which of the following most accurately relates to a malnourished patient?

Select the single most appropriate answer.

A. Albumin below 3.5 g/dl
B. Body mass index (BMI) under 21 kg/m^2
C. Recurrent skin ulceration
D. Serum haemoglobin below 12 g/dl
E. Waist size within two standard deviations of normal for height

16. Which of the following is the gold standard for measurement of vascular inflow?

Select the single most appropriate answer.

A. Ankle–brachial pressure index
B. Capillary refill time
C. Distal pulse Doppler and skin temperature assessment
D. Percutaneous oxygen saturation
E. Percutaneous oxygen tension

17. What is the ischaemic index?

Select the single most appropriate answer.

A. A comparative measure of capillary refill time between an affected lower limb and the normal unaffected upper limb
B. A quantity that relates to the comparative oxygen saturation in the distal tissue of a limb
C. A quantity that should be less than 0.3 to achieve wound healing
D. The ratio of Doppler pressure at the level being tested to the brachial systolic pressure
E. The ratio of oxygen tension between the same level of an affected compared with an unaffected limb

18. A 76-year-old post-menopausal woman presents to the fracture clinic. She was walking her poodle and tripped over its lead, sustaining a distal radial fracture which is minimally displaced. She has previously fractured her lumbar spine (falling off a bar stool) and her ankle (she tripped in very high heels). What treatment would you suggest?

What treatment would you suggest?

Select the single most appropriate answer.

A. 6 weeks in plaster/splint and review in fracture clinic
B. 6 weeks in plaster/splint, review in fracture clinic, modification of lifestyle, and reduction of alcohol intake
C. 6 weeks in plaster/splint, review in fracture clinic, and referral for falls prevention assessment
D. 6 weeks in plaster/splint, review in fracture clinic, and referral for a DEXA (bone density) scan
E. 6 weeks in plaster/splint, review in fracture clinic, start alendronate, and refer to the fracture liaison service

19. A 36-year-old woman is treated for a minimally displaced fractured ankle with 6 weeks in a full cast then 4 weeks of physiotherapy. At final review her foot is painful, red, and swollen. Which imaging modality is specific for diagnosing complex regional pain syndrome (CRPS type I)?

Select the single most appropriate answer.

A. Conventional magnetic resonance imaging (MRI)
B. Conventional plain radiography
C. Gadolinium-enhanced MRI
D. Nuclear medicine bone scan and leucoscan
E. None of the above

chapter
1

BASIC SCIENCE OF ORTHOPAEDIC TRAUMA

Answers

1. D. Formation of granulation tissue

For contact healing to occur a fracture must be anatomically reduced and be absolutely stable. This occurs through the use of devices, which cause interfragmentary compression resulting in strain environments often far less than 2%. Granulation tissue is not observed in this type of healing. It is formed in high strain of up to 100% and its formation occurs in the initial phases of secondary bone healing.

Bates P, Ramachandran M (2006). Bone injury, healing and grafting. In: M Ramachandran (ed.) *Basic Orthopaedic Sciences—the Stanmore Guide*, 1st edn, pp.123–134. CRC/Taylor and Francis, London.

2. D. Remodelling

Primary bone healing occurs through the simultaneous resorption of bone by osteoclasts and production of bone by osteoblasts. This process also occurs as the woven bone formed in secondary bone healing matures to lamellar bone in the remodelling phase.

Bates P, Ramachandran M (2006). Bone injury, healing and grafting. In: M Ramachandran (ed.) *Basic Orthopaedic Sciences—the Stanmore Guide*, 1st edn, pp.123–134. CRC/Taylor and Francis, London.

3. B. They form bridging osteons that mature into lamellar bone by direct remodelling

Primary healing of fractures can occur either through contact healing or by gap healing. Both processes involve an attempt to directly re-establish an anatomically correct and biomechanically competent lamellar bone structure. Direct bone healing can only occur when an anatomical restoration of the fracture fragments is achieved and rigid fixation is provided, resulting in a substantial decrease in interfragmentary strain. Bone on one side of the cortex must unite with bone on the other side of the cortex to re-establish mechanical continuity. If the gap between bone ends is less than 0.01 mm and interfragmentary strain is less than 2% the fracture unites by so-called contact healing. Under these conditions, cutting cones are formed at the ends of the osteons closest to the fracture site. The tips of the cutting cones consist of osteoclasts that cross the fracture line, generating longitudinal cavities at a rate of 50–100 μm/day. These cavities are later filled by bone produced by osteoblasts residing at the rear of the cutting cone. This results in the simultaneous (*not* sequential) generation of a bony union and the restoration of Haversian systems formed in an axial direction. The re-established Haversian systems allow for penetration of blood vessels carrying osteoblastic precursors. The bridging osteons later mature by direct remodelling into lamellar bone, resulting in fracture healing without the formation of periosteal callus.

Marsell R, Einhorn TA (2011). Biology of fracture healing. *Injury*, 42, 551–555.

4. D. Simultaneous generation of a bony union and the restoration of Haversian systems

Gap healing differs from contact healing in that bony union and Haversian remodelling do not occur simultaneously. Gap healing occurs if stable conditions and an anatomical reduction are achieved,

although the gap must be less than 800 μm to 1 mm. In this process the fracture site is primarily filled by lamellar bone (akin to intramembranous ossification) oriented perpendicular to the long axis, requiring a secondary osteonal reconstruction unlike the process of contact healing. The primary bone structure is then gradually replaced by longitudinal revascularized osteons carrying osteoprogenitor cells that differentiate into osteoblasts and produce lamellar bone on each surface of the gap. This lamellar bone, however, is laid down perpendicular to the long axis and is mechanically weak. This initial process takes approximately 3 to 8 weeks, after which a secondary remodelling resembling the contact healing cascade with cutting cones takes place. Although not as extensive as endochondral remodelling, this phase is necessary in order to fully restore the anatomical and biomechanical properties of the bone.

Marsell R, Einhorn TA (2011). Biology of fracture healing. *Injury*, 42, 551–555.

5. E. Less than 2%

Granulation tissue will form in strain environments up to 100%; fibrous connective tissue will form up to 17%, fibrocartilage in the range 2–10%, and lamellar bone at less than 2%.

Bates P, Ramachandran M (2006). Bone injury, healing and grafting. In: M Ramachandran (ed.) *Basic Orthopaedic Sciences—the Stanmore Guide*, 1st edn, pp.123–134. CRC/Taylor and Francis, London.

6. D. Periosteal callus

Periosteal callus is formed by the same mechanism as intramembranous ossification (the method through which increases in the diameter of the bone are achieved). Periosteum has an inner loose vascular osteogenic (cambium) layer which contains pluripotent cells. Following trauma, provided that relative stability is present and the periosteum has not been extensively stripped, the pluripotent cells become osteoprogenitor cells which in turn become osteoblasts and bone is laid down without first forming cartilage.

Bates P, Ramachandran M (2006). Bone injury, healing and grafting. In: M Ramachandran (ed.) *Basic Orthopaedic Sciences—the Stanmore Guide*, 1st edn, pp.123–134. CRC/Taylor and Francis, London.

Marsell R, Einhorn TA (2011). Biology of fracture healing. *Injury*, 42, 551–555.

Perren S (2002). Evolution of the internal fixation of long bone fractures the scientific basis of biological internal fixation: choosing a new balance between stability and biology. *J Bone Joint Surg Br*, 84, 1093–1110.

7. D. IL-1 (interleukin 1)

The TGF-β superfamily is a group of structurally related cell regulatory proteins named after its first member TGF-β1—a secreted protein that controls cell growth, cell proliferation, cell differentiation, and apoptosis. BMPs 2–7 and 9 are members of the TGF-β superfamily and play key roles in the differentiation of osteoblasts from osteoprogenitor cells: BMP3 antagonizes these BMPs, BMP4 is vital in fracture repair as it promotes endochondral bone formation, BMP5 is essential to cartilage development, and BMP6 plays a role in joint integrity in adults. GDF2 (also known as BMP9) is one of the most potent inducers of bone formation. It is a member of the TGF-β superfamily. Activin enhances the synthesis and secretion of follicle-stimulating hormone (FSH). It is a member of the TGF-β superfamily but is not involved in fracture healing or bone formation.

IL-1 is a pro-inflammatory cytokine, intensely produced by macrophages, monocytes, and fibroblasts. It is a vital part of the initial haematoma and inflammation stages of callus formation. It promotes angiogenesis and causes osteoblasts to secrete IL-6, which in turn causes further differentiation of osteoblasts and osteoclasts. It also increases the expression of adhesion factors on endothelial cells, facilitating migration of immunocompetent cells. It is also a pyrogen, causes vasodilatation and hypotension, and increases pain sensitivity. It is seen at all sites of inflammation and infection. However, it is not a member of the TGF-β superfamily.

Bates P, Ramachandran M (2006). Bone injury, healing and grafting. In: M Ramachandran (ed.) *Basic Orthopaedic Sciences—the Stanmore Guide*, 1st edn, pp.123–134. CRC/Taylor and Francis, London.

Marsell R, Einhorn TA (2011). Biology of fracture healing. *Injury*, 42, 551–555.

Perren S (2002). Evolution of the internal fixation of long bone fractures the scientific basis of biological internal fixation: choosing a new balance between stability and biology. *J Bone Joint Surg Br*, 84, 1093–1110.

8. D. 2–10%

Soft callus is primarily endochondral callus. It may also be referred to as bridging external callus. It is formed when pluripotent cells within granulation tissue differentiate into chondrocytes and fibroblasts and start to produce fibrous/chondroid elements of the matrix onto which type collagen II is then deposited. Calcification of the matrix results in calcified fibrocartilage. At high strain up to 100% granulation tissue will form, between 10% and 17% fibrous connective tissue will form. In order to get fibrocartilage formation the strain must be between 2% and 10%. Below 2% strain bone formation can occur.

Bates P, Ramachandran M (2006). Bone injury, healing and grafting. In: M Ramachandran (ed.) *Basic Orthopaedic Sciences—the Stanmore Guide*, 1st edn, pp.123–134. CRC/Taylor and Francis, London.

Marsell R, Einhorn TA (2011). Biology of fracture healing. *Injury*, 42, 551–555.

Perren S (2002). Evolution of the internal fixation of long bone fractures the scientific basis of biological internal fixation: choosing a new balance between stability and biology. *J Bone Joint Surg Br*, 84, 1093–1110.

9. A. Angiopoetin-12 is a regulator of vascular regeneration and neoangiogenesis

Endochondral callus formation can only occur if mesenchymal stem cells can be recruited to the fracture site, where they proliferate and differentiate into osteogenic cells. Revascularization is also fundamental to callus formation. Mesenchymal stem cells are sourced from both local tissues and remote haemopoietic sites. Revascularization and neoangiogenesis are highly dependent on the VEGF pathway initiated by expression of VEGF by osteoblasts and hypertrophic chondrocytes. Angiopoetin-1 and angiopoetin-2 are involved in the early in-growth of existing vessels in the periosteum. Angiopoetin-12 does not exist.

Bates P, Ramachandran M (2006). Bone injury, healing and grafting. In: M Ramachandran (ed.) *Basic Orthopaedic Sciences—the Stanmore Guide*, 1st edn, pp.123–134. CRC/Taylor and Francis, London.

Marsell R, Einhorn TA (2011). Biology of fracture healing. *Injury*, 42, 551–555.

Perren S (2002). Evolution of the internal fixation of long bone fractures the scientific basis of biological internal fixation: choosing a new balance between stability and biology. *J Bone Joint Surg Br*, 84, 1093–1110.

10. D. Osteoclast apoptosis

During the replacement of soft cartilaginous callus by hard woven bone all the steps shown occur with the exception of osteoclast apoptosis.

Bates P, Ramachandran M (2006). Bone injury, healing and grafting. In: M Ramachandran (ed.) *Basic Orthopaedic Sciences—the Stanmore Guide*, 1st edn, pp.123–134. CRC/Taylor and Francis, London.

Marsell R, Einhorn TA (2011). Biology of fracture healing. *Injury*, 42, 551–555.

Perren S (2002). Evolution of the internal fixation of long bone fractures the scientific basis of biological internal fixation: choosing a new balance between stability and biology. *J Bone Joint Surg Br*, 84, 1093–1110.

11. B. Reduce fracture anatomically, 3.5 mm drill for gliding hole, 2.5 mm drill for pilot hole, countersink, measure, tap, screw

An interfragmentary compression, or lag, screw has several crucial steps that must not be performed out of sequence.

AO Foundation—lag screw fixation: https://www2.aofoundation.org/wps/portal/!ut/p/c0/04_SB8K8xLLM9MSSzPy8xBz9CP0os3hng7BARydDRwN3QwMDA08zTzdvvxBjIwN_I_2CbEdFADiM_QM!/?segment=Mandible&bone=CMF&showPage=A&contentUrl=srg/popup/additional_material/91/X80_lag_screw_fix.jsp

12. B. The working length of a monocortical locked screw is the distance between the undersurface of the plate and the bone

The working length of a monocortical locked screw is the length of screw seated in the cortex of the bone. It is thus dependent on the thickness of the cortex, and is as a result greatly reduced in osteoporotic bone. The number of screws, screw diameter, and type of screw are independent of the working length in monocortical locking.

Gautier E, Sommer C (2003). Guidelines for the clinical application of the LCP. *Injury*, 34(Suppl. 2), B63–B76.

13. B. The locking screws have a relatively greater core diameter

The screws used with conventional plates are designed to compress the plate onto the bone to increase friction. A key feature of a conventional screw is therefore its pull-out strength. The screws used with locking plates function as a unified fixed angle device; as they act together their absolute and individual pull-out strengths are less important than their ability to resist bending forces. It follows, therefore, that their core diameter should be relatively large (bending stiffness being proportional to the fourth power of the radius) whilst their threads do not need to be as wide.

Gautier E, Sommer C (2003). Guidelines for the clinical application of the LCP. *Injury*, 34(Suppl. 2), B63–B76.

14. A. Less stiff in proportion to the fourth power of the inner radius

This question deals with the concept of the second moment of area. For an extruded shape of circular cross-section the bending stiffness and the torsional stiffness are both proportional to the fourth power of the radius. For a hollow cylindrical shape the second moment of area is proportional to the fourth power of the outer radius minus the fourth power of the inner radius. Thus, for two cylinders of the same outer diameter the solid one will be stiffer. The 'strength' is proportional to the third power of the radius. The overall stiffness depends on the elastic modulus of the material, the second moment of area of the device, and the working length.

Ramachandran M (ed.) (2006). *Basic Orthopaedic Sciences—the Stanmore Guide*, 1st edn. CRC/Taylor and Francis, London.

15. A. Albumin below 3.5 g/dl

Serum albumin represents the most accurate means of assessing someone's nutritional status. Low BMI, waist size, and haemoglobin may determine wound-healing capacity but only indirectly reflect nutritional status.

Kram HB, Appel PL, Shoemaker WC (1989). Prediction of below-knee amputation wound healing using noninvasive laser Doppler velocimetry. *Am J Surg*, 158, 29–31.

Mulder GD, Brazinsky K, Harding KG (1998). Factors influencing wound healing. In: Leaper D, Harding KG (eds) *Wounds: Biology and Management*, Oxford University Press, Oxford.

16. E. Percutaneous oxygen tension

Percutaneous oxygen tension is the gold standard for measuring vascular inflow. The other measurements are crude tests of limb perfusion.

Wütschert R, Bounameaux H (1997). Determination of amputation level in ischemic limbs. Reappraisal of the measurement of TcPo2. *Diabetes Care*, 20, 1315–1318.

17. D. The ratio of Doppler pressure at the level being tested to the brachial systolic pressure

The ratio of Doppler pressure at the level being tested to the brachial systolic pressure defines the ischaemic index of the limb.

Kram HB, Appel PL, Shoemaker WC (1989). Prediction of below-knee amputation wound healing using noninvasive laser Doppler velocimetry. *Am J Surg*, 158, 29–31.

Mulder GD, Brazinsky K, Harding KG (1998). Factors influencing wound healing. In: Leaper D, Harding KG (eds) *Wounds: Biology and Management*, Oxford University Press, Oxford.

18. E. 6 weeks in plaster/splint, review in fracture clinic, start alendronate, and refer to the fracture liaison service

Suspected osteoporosis in the over 75s may not need a DEXA scan for diagnosis according to NICE guidelines. A post-menopausal woman with a fracture is offered treatment for osteoporosis depending on her risk factors. Alendronate is recommended in post-menopausal women who have had a diagnosis of osteoporosis as a first-line treatment for preventing further fractures. If alendronate is not tolerated alternatives include risendronate, etidronate, strontium ranelate, raloxifene, and teriparatide. Teriparatide is also recommended if a woman has another fracture and her bone density has fallen whilst taking alendronate, risendronate, or etidronate. Fracture liaison services should be provided in all orthopaedic clinics—they will address all required aspects of the management of osteoporosis outlined in options B–E.

FRAX. WHO fracture risk assessment tool. http://www.shef.ac.uk/FRAX/

Giger, EV, Castagner B, Leroux JC (2013). Biomedical applications of bisphosphonates. *J Control Release*, 167, 175–188.

National Institute for Health and Care Excellence (NICE). NICE technology appraisal guidance TA161. Alendronate, etidronate, risedronate, raloxifene, strontium ranelate and teriparatide for the secondary prevention of osteoporotic fragility fractures in postmenopausal women (amended). http://www.nice.org.uk/guidance/TA161

19. E. None of the above

CRPS type I can develop following a fracture in 10% of subjects. It is characterized by pain, abnormal regulation of blood flow, sweating, and trophic changes divided into three phases. Phase 1: vasomotor response, swelling and vasodilatation, less than 3 months from injury. Phase 2: dystrophic phase, vasoconstriction, increased stiffness, 3 months to a year from injury. Phase 3: atrophic phase, fibrosis, contracture, a year from injury. CRPS affects both the central and peripheral nervous systems but the cause is still unknown. Various hypotheses, including distal degeneration of nerve fibres, autoimmune involvement, and an association with angiotensin-converting-enzyme (ACE) inhibitors, have been postulated. Imaging modalities are not specific for the diagnosis of CRPS but functional MRI (fMRI) has recently shown promising results. Treatment focuses on tricyclic antidepressants, opioids, and selective neural blockade such as guanethidine blocks, but conventional therapies produce an unpredictable outcome.

Hsu ES (2009). Practical management of complex regional pain syndrome. *Am J Ther*, 16, 147–154.

Maihofner C, Handwerker HO, Birklein F(2006). Functional imaging of allodynia in complex regional pain syndrome. *Neurology*, 66, 711–717.

Schumann M, Zaspel J, Lohr P, et al. (2007). Imaging in early posttraumatic complex regional pain syndrome: a comparison of diagnostic methods. *Clin J Pain*, 23, 449–457.

chapter
2

ADVANCED TRAUMA LIFE SUPPORT (ATLS), POLYTRAUMA, LIMB SALVAGE, AND UK TRAUMA GUIDELINES

Questions

1. A 29-year-old soldier steps on a landmine on the battlefield. He starts to bleed profusely from a mangled left leg. What is the initial treatment?

Select the single most appropriate answer.

A. A battlefield tourniquet should be applied to the limb
B. A clean dressing with a military pressure bandage
C. A haemostatic dressing should be applied immediately
D. Application of a pneumatic tourniquet
E. Immediate evacuation from the battlefield

2. Which of these statements is incorrect with regard to ATLS teaching on head trauma?

Select the single most appropriate answer.

A. Epidural haematomas occur in 2% of patients with traumatic brain injury who are comatose
B. Epidural haematomas typically become biconvex or lenticular in shape as they push the adherent dura away from the inner table of the skull
C. Epidural haematomas are most often located in the temporal or temporoparietal regions
D. Epidural haematomas often result from a tear of the middle meningeal artery as the result of a fracture
E. Epidural haematomas classically present with a lucid interval between time of injury and neurological deterioration

3. Which of the following is not a principle of the ATLS management of severe head injury?

Select the single most appropriate answer.

A. Evacuate haematomas that increase intracranial volume
B. Maintain a low mean arterial blood pressure
C. Maintain normal intravascular volume
D. Reduce elevated intracranial pressure
E. Restore normal oxygenation and normocapnia

4. Which of these statements is not found in the ATLS management of paediatric shock?

Select the single most appropriate answer.

A. Fluid resuscitation in children should start with an isotonic fluid bolus of 50 ml/kg
B. Hypotension occurs late in paediatric hypovolaemic shock and represents a state of decompensated shock
C. If the child deteriorates during fluid resuscitation consideration must be given to the early use of 10 ml/kg of packed red blood cells
D. The mean normal systolic blood pressure in a child is approximately 90 mmHg plus twice the child's age in years
E. The weight of a child in kilograms can be estimated using the formula (2 × age in years) + 10

5. Which of the following is not a conclusion of the multicentre prospective observational Lower Extremity Assessment Project (LEAP)?

Select the single most appropriate answer.

A. Initial plantar sensation is prognostic of long-term functional outcome and should be a component of a limb-salvage decision algorithm
B. More attention to the psychological as well as the physical health of patients who sustain a limb-threatening injury may be needed to ensure an optimal recovery
C. Patients with severe, bilateral lower extremity injuries should be counselled that, regardless of treatment combinations, the function of each limb is similar at 2 and 7 years
D. Severity of soft tissue injury has the greatest impact on decision-making regarding limb salvage versus amputation
E. Smoking places the patient at risk for increased time to union and complications

6. The LEAP study identified a number of early predictors of chronic pain. Which of these is not predictive of chronic pain after limb-threatening trauma?

Select the single most appropriate answer.

A. Evidence of depression and anxiety at 3 months post-discharge
B. High average alcohol consumption at baseline
C. High levels of sleep dysfunction
D. Lack of higher education
E. Treatment with narcotic medication during the first 3 months

7. The LEAP study included a subset of 268 unilateral open tibial fractures. The study group reported on the effect of smoking in this group. Which of the following statements is incorrect?

Select the single most appropriate answer.

A. Current smokers are 37% less likely to achieve union than non-smokers
B. Current smokers are approximately 3.5 times more likely to develop osteomyelitis than non-smokers
C. Current smokers are approximately five times more likely to develop an infection than non-smokers
D. Previous smokers are 32% less likely to achieve union than non-smokers
E. Previous smokers are approximately three times more likely to develop osteomyelitis than non-smokers

8. A motorcyclist is involved in a road traffic accident (RTA) where he hits a stationary object at approximately 50 m.p.h. At the scene he has a pulse rate of 100 b.p.m. and a blood pressure of 140/80. He is taken to the nearest major trauma centre with a hard collar on a spinal board. On arrival he has a primary survey. His pelvic radiograph shows an anteroposterior compression type II pelvic fracture. Which of the following should be avoided?

Select the single most appropriate answer.

A. Application of a pelvic binder if one has not already been applied by paramedics
B. Continue close monitoring with a low threshold for initiation of a massive transfusion protocol
C. Examination of the perineum
D. Log roll the patient to examine the spine for associated injuries
E. Perform a trauma series CT with contrast as early as possible

9. What is the Injury Severity Score (ISS) for a patient with a penetrating chest wound (Abbreviated Injury Scale, AIS = 4), liver laceration (AIS = 4), open tibial shaft fracture (AIS = 3), distal radius fracture (AIS = 2), and a large scalp laceration (AIS = 1)?

Select the single most appropriate answer.

A. 11
B. 14
C. 32
D. 41
E. 46

10. What is the Modified Injury Severity Score (MISS) for a child with a Glasgow Coma Scale (GCS) score of 14, severe but not life-threatening femoral fracture (3 points), moderate abdominal injury (2 points), and severe but probably survivable neck injury (4 points)?

Select the single most appropriate answer.

A. 9
B. 10
C. 29
D. 30
E. 39

11. Which of the following would not be an indication for initial temporary fixation of a femoral shaft fracture?

Select the single most appropriate answer.

A. Closed head injury
B. Contralateral femoral shaft fracture
C. Flail chest and underlying lung contusion
D. Ipsilateral tibial fracture
E. Lactate of –5.0 mmol/L

12. A 91-year-old woman with Alzheimer's is found on the floor of her nursing home bathroom. She presents with a displaced intracapsular femoral neck fracture. She is dehydrated, confused, and has a urinary tract infection. She has chronic obstructive pulmonary disease (COPD) and atrial fibrillation (warfarin), and had a coronary artery bypass graft (CABG) 10 years ago. After optimization (including warfarin reversal) she remains frail with poor cardiorespiratory reserve. What treatment should be suggested?

Select the single most appropriate answer.

A. Cemented hemiarthroplasty on the next routine trauma list
B. Cemented taper slip design total hip arthroplasty
C. Non-operative management with analgesia
D. Open reduction and internal fixation with cannulated screws
E. Uncemented (Thompson/Austin Moore) hemiarthroplasty on the next routine trauma list

13. The incidence of unstable spine injuries in unconscious patients with significant blunt trauma is . . . ?

Select the single most appropriate answer.

A. Up to 11%
B. Up to 34%
C. Up to 23%
D. Up to 29%
E. Over 41%

14. According to the British Orthopaedic Association Standards for Trauma (BOAST), spinal immobilization is recommended for . . . ?

Select the single most appropriate answer.

A. As long as is necessary
B. Less than 12 hours
C. Not more than 48 hours
D. Not more than 24 hours
E. None of above

15. Which of the following is the urgent investigation of choice for a spinal cord injury?

Select the single most appropriate answer.

A. Anteroposterior and lateral radiograph of entire spine
B. MRI
C. Positron emission tomography (PET)-CT scan
D. 2–3 mm fine-slice helical computed tomography (CT) scan
E. < 5 mm helical CT scans

16. A 38-year-old man is involved in a RTA and sustains a posterior dislocation of his right hip, with a small posterior acetabular wall fracture. It is an isolated injury with no neurological deficit, he is otherwise well, and is haemodynamically stable. What is the most appropriate next step in his treatment?

Select the single most appropriate answer.

A. CT scan the next day
B. Open reduction and internal fixation of the posterior wall fracture
C. Open reduction of the dislocation and excision of the bony fragment
D. Skin traction and transfer to an acetabular reconstruction expert
E. Urgent closed reduction and assessment of hip stability post-reduction

17. What is the maximum acceptable time delay for vascular reconstruction if confirmed vascular impairment exists in a lower limb?

Select the single most appropriate answer.

A. 8 hours of cold ischaemia
B. 6 hours of warm ischaemia
C. 3–4 hours of warm ischaemia
D. It depends on coexisting soft/bone tissue injury
E. Not defined

18. Following initial wound excision, which antibiotics should be administered for an open fracture?

Select the single most appropriate answer.

A. Amoxicillin and meropenem
B. Cefuroxime and metronidazole
C. Clindamycin
D. Co-amoxiclav and gentamicin
E. Tobramycin and cefuroxime

19. In an open fracture, following wound, soft tissue, and bone excision, for what duration should antibiotics be given?

Select the single most appropriate answer.

A. 5 days
B. 10–14 days
C. 72 hours or until definitive wound closure (whichever is sooner)
D. Indefinitely
E. It depends on microbiology advice

20. Which of the following scores is not a risk factor for venous thromboembolism (VTE)?

Select the single most appropriate answer.

A. Acute stroke
B. Admission to critical care
C. A first-degree relative with a history of VTE
D. Obesity (BMI > 30 kg/m^2)
E. Varicose veins

chapter
2

ADVANCED TRAUMA LIFE SUPPORT (ATLS), POLYTRAUMA, LIMB SALVAGE, AND UK TRAUMA GUIDELINES

Answers

1. A. A battlefield tourniquet should be applied to the limb

Early use of a tourniquet in combat situations has led to a reduction in morbidity from haemorrhagic limb injuries.

Kragh JF Jr (2010). Use of tourniquets and their effects on limb function in the modern combat environment. *Foot Ankle Clin*, 15, 23–40.

Richey SL (2009). Tourniquets for the control of traumatic haemorrhage: a review of the literature. *J Spec Operations Med*, 9, 56–64.

2. A. Epidural haematomas occur in 2% of patients with traumatic brain injury who are comatose

Though relatively uncommon overall (0.5% of all brain injuries), epidural haematomas occur in 9% of comatose patients with traumatic brain injury. The other statements are all correct.

American College of Surgeons (2012). *Advanced Trauma Life Support (ATLS) Student Course Manual*, 9th edn, Chapter 6. American College of Surgeons,

3. B. Maintain a low mean arterial blood pressure

Maintenance of normal mean arterial blood pressure (MAP) is necessary. The primary goal of treatment for patients with suspected traumatic brain injury is to prevent secondary brain injury. Providing adequate oxygenation and maintaining blood pressure at a level that is sufficient to perfuse the brain are the most important ways to limit secondary brain damage.

Cerebral perfusion pressure (CPP) = MAP – intracranial pressure (ICP)

Elevation of ICP can reduce cerebral perfusion and cause or exacerbate ischaemia, especially where MAP is reduced. The normal ICP in the resting state is approximately 10 mmHg. Pressures greater than 20 mmHg, particularly if sustained and refractory to treatment, are associated with poor outcomes.

American College of Surgeons (2012). *Advanced Trauma Life Support (ATLS) Student Course Manual*, 9th edn, Chapter 6. American College of Surgeons,

4. A. Fluid resuscitation in children should start with an isotonic fluid bolus of 50 ml/kg

The current (ninth) edition of the ATLS Manual recommends that fluid resuscitation be commenced with an isotonic fluid bolus of 20 ml/kg. A diminution in circulating blood volume of up to 30% may be required to manifest a decrease in the child's systolic blood pressure. Tachycardia and poor skin perfusion are often the only keys to early recognition of hypovolaemia. Although a child's primary response to hypovolaemia is tachycardia, this sign also may be caused by pain, fear, or psychological stress. A decrease in blood pressure and other indices of inadequate organ perfusion, such as urinary output, should be monitored closely, but generally develop later.

American College of Surgeons (2012). *Advanced Trauma Life Support (ATLS) Student Course Manual*, 9th edn, Chapter 10. American College of Surgeons,

5. A. Initial plantar sensation is prognostic of long-term functional outcome and should be a component of a limb-salvage decision algorithm

Five hundred and twenty-seven eligible patients between the ages of 16 and 69 with Gustilo-type IIIB and IIIC tibial fractures, avascular limbs resulting from trauma, type IIIB ankle fractures, or severe open midfoot or hindfoot injuries were included in the LEAP study. This study included a subset of 55 patients with an insensate foot at presentation. Twenty-nine of these patients underwent limb salvage. More than half of this group ultimately regained sensation by 2 years. The LEAP Study Group concluded that initial plantar sensation is *not* prognostic of long-term plantar sensory status or functional outcomes and should not be a component of a limb-salvage decision algorithm. Options B–E are all conclusions of the various publications of LEAP study groups.

Bosse MJ, McCarthy ML, Jones AL, et al. (2005). Lower Extremity Assessment Project (LEAP) Study Group. The insensate foot following severe lower extremity trauma: an indication for amputation? *J Bone Joint Surg Am*, 87, 2601–2608.

6. E. Treatment with narcotic medication during the first 3 months

Chronic pain is significantly more common following severe lower extremity trauma than in the general population. The LEAP Study Group identified that less than a high school education and low self-efficacy for return to usual major activities were significant risk factors for developing chronic pain. The LEAP Study Group suggested that these high-risk patients may benefit from early referral to pain management, as patients treated with narcotic medication during the first 3 months post-discharge had lower levels of chronic pain at 7 months. They may also benefit from psychological evaluation and treatment.

Castillo RC, MacKenzie EJ, Wegener ST, Bosse MJ; LEAP Study Group (2006). Prevalence of chronic pain seven years following limb threatening lower extremity trauma. *Pain*, 124, 321–329.

7. C. Current smokers are approximately five times more likely to develop an infection than non-smokers

Patients in the current smokers group were twice as likely to develop an infection and 3.7 times more likely to develop osteomyelitis than non-smokers. Previous smokers were at no greater risk of other infections but were still 2.8 times more likely to develop osteomyelitis than non-smokers.

Castillo RC, Bosse MJ, MacKenzie EJ, Patterson BM; LEAP Study Group (2005). Impact of smoking on fracture healing and risk of complications in limb-threatening open tibia fractures. *J Orthop Trauma*, 19, 151–157.

8. D. Log roll the patient to examine the spine for associated injuries

Log rolling a patient with a potentially unstable pelvic ring injury is contraindicated. This risks mechanical disturbance to the clot that has formed in the retroperitoneum. This clot will contain a large proportion of the body's clotting factors and platelets, meaning there is low reserve for the formation of a further clot. A retrograde urethrogram would not be considered in the primary survey; however, an examination of the perineum for open injuries and ecchymosis must be carried out and documented.

American College of Surgeons (2012). *Advanced Trauma Life Support (ATLS) Student Course Manual*, 9th edn, Chapter ?. American College of Surgeons,

9. D. 41

The ISS is a system that provides an overall score for patients with multiple injuries. Each injury is assigned an AIS score from 1 (minor) to 6 (not survivable) and is allocated to one of six body regions

(head, face, chest, abdomen, extremities and pelvis, external). Only the single highest AIS score in each body region is used. The three most severely injured body regions have their score squared and added together to produce the ISS score. Scores range from 0 to 75 ($5^2 + 5^2 + 5^2$), but if any body region has an AIS of 6 (not survivable) then the ISS is automatically given as 75. Major trauma is usually defined as an ISS of greater than 15. In this case the three most severely injured regions are the chest, abdomen, and extremities, giving an ISS of $4^2 + 4^2 + 3^2 = 41$.

Baker SP, O'Neill B, Haddon W Jr, Long WB (1974). The Injury Severity Score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma*, 14, 187–196.

10. C. 29

The MISS is a trauma scoring system for paediatric patients. It operates along similar lines to the ISS but with five body regions (neurological, face and neck, chest, abdomen and pelvic contents, extremities and pelvic girdle) scored from 1 (minor) to 5 (critical with uncertain survival). As with the ISS, the total score is the sum of the squares of the three most severely injured body regions. For MISS scores greater than 40 mortality is 50%, and for scores greater than 50 mortality is 75%. In this case a GCS of 14 would give a neurological score of just 1, so the three most severely injured regions are face and neck, extremities, and abdomen, giving a MISS of $4^2 + 3^2 + 2^2 = 29$.

Mayer T, Matlak ME, Johnson DG, Walker ML (1980). The modified injury severity scale in pediatric multiple trauma patients. *J Pediatr Surg*, 15, 719–726.

11. D. Ipsilateral tibial fracture

Early stabilization of long bone fractures is beneficial, but in certain situations damage control surgery with external fixation and later conversion to intramedullary nailing might be indicated. This may be considered in situations where both femurs are fractured or where the patient's physiology is clearly impaired, as demonstrated by an altered base excess or lactate. It should also be considered if other injuries are present that might be impacted by intramedullary nailing, such as head and chest injuries. An ipsilateral tibial fracture as an isolated finding would not necessarily require temporising fixation, but may be a relative indication for a retrograde femoral nail.

Brumback RJ, Virkus WW (2000). Intramedullary nailing of the femur: reamed versus nonreamed. *J Am Acad Orthop Surg*, 8, 83–90.

Canadian Orthopaedic Trauma Society (2003). Nonunion following intramedullary nailing of the femur with and without reaming. Results of a multicenter randomized clinical trial. *J Bone Joint Surg Am*, 85-A, 2093–2096.

12. A. Cemented hemiarthroplasty on the next routine trauma list

Non-operative management is associated with high morbidity and a low chance of regaining independent mobility. A recent trial in nonagenarians found similar mortality in both groups, but better function in those who received surgery. Surgery should be the default option, even if only for palliation of pain. NICE guidance recommends arthroplasty for displaced intracapsular fractures in elderly patients. As this patient has a low level of functional demand, total hip arthroplasty is inappropriate. NICE further recommends that, when considering arthroplasty, implants should be cemented. Uncemented (e.g. an Austin Moore prosthesis) designs have a higher rate of pain, loosening, and need for revision. There is no increase in 30-day mortality with the use of cemented implants and functional outcomes are better with cemented systems.

Handoll HHG, Parker MJ (2008). Conservative versus operative treatment for hip fractures in adults. *Cochrane Database Syst Rev*, 3: CD000337.

National Institute for Health and Care Excellence (NICE) (2011). Hip fracture: the management of hip fracture in adults. *NICE Guideline CG124*. https://www.nice.org.uk/guidance/cg124

Ooi LH1, Wong TH, Toh CL, Wong HP (2005). Hip fractures in nonagenarians—a study on operative and non-operative management. *Injury*, 36, 142–147.

Parker MI1, Pryor G, Gurusamy K (2010). Cemented versus uncemented hemiarthroplasty for intracapsular hip fractures: a randomised controlled trial in 400 patients. *J Bone Joint Surg Br*, 92, 116–122.

13. B. Up to 34%

The incidence of unstable spine injuries in unconscious patients with significant blunt trauma is 34%. The British Orthopaedic Association has issued guidance on spinal clearance in the trauma patient (BOAST 2).

British Orthopaedic Association (2008). BOAST 2: Spinal clearance in the trauma patient. https://www.boa.ac.uk/wp-content/uploads/2014/05/BOAST-2-Spinal-clearance-in-the-Trauma-Patient.pdf

14. C. Not more than 48 hours

The spine should not be immobilised for more than 48 hours; by this time three-point stabilisation should be removed and a definitive management plan actioned. The British Orthopaedic Association has issued guidance on spinal clearance in the trauma patient (BOAST 2).

British Orthopaedic Association (2008). BOAST 2: Spinal clearance in the trauma patient. https://www.boa.ac.uk/wp-content/uploads/2014/05/BOAST-2-Spinal-clearance-in-the-Trauma-Patient.pdf

15. B. MRI

MRI is the imaging technique of choice in all patients with suspected spinal cord injury. The British Orthopaedic Association has issued guidance on spinal clearance in the trauma patient (BOAST 2).

British Orthopaedic Association (2008). BOAST 2: Spinal clearance in the trauma patient. https://www.boa.ac.uk/wp-content/uploads/2014/05/BOAST-2-Spinal-clearance-in-the-Trauma-Patient.pdf

16. E. Urgent closed reduction and assessment of hip stability post-reduction

Hip dislocations must be reduced urgently and then an assessment of stability recorded. The neurovascular status before and after reduction must be documented. Skeletal traction should then be applied. If the hip remains irreducible or unstable, then urgent advice should be sought from a specialist in acetabular reconstruction and immediate transfer should be considered. Following reduction a CT scan must be done within 24 hours to exclude bony entrapment and to assess hip congruence and the extent of any fracture. If the hip is stable and the joint is congruent then surgery may not be required. The British Orthopaedic Association has issued guidance on the management of patients with pelvic and acetabular fractures (BOAST 3).

British Orthopaedic Association (2008). BOAST 3: pelvic and acetabular fracture management. https://www.boa.ac.uk/wp-content/uploads/2014/12/BOAST-3.pdf

Grimshaw CS, Moed BR (2010). Outcomes of posterior wall fractures of the acetabulum treated nonoperatively after diagnostic screening with dynamic stress examination under anesthesia. *J Bone Joint Surg Am*, 92, 2792–2800.

17. B. 6 hours of warm ischaemia

Six hours of warm ischaemia represents the amount of time it takes for irreversible ischaemic damage to occur in muscle tissue. The British Orthopaedic Association has issued guidance on the management of severe open lower limb fractures (BOAST 4).

British Orthopaedic Association (2009). BOAST 4: the management of severe open lower limb fractures. https://www.boa.ac.uk/wp-content/uploads/2014/12/BOAST-4.pdf

18. D. Co-amoxiclav and gentamicin

Augmentin plus gentamicin should be administered at the time of debridement. Vancomycin should be given at skeletal stabilization. The British Orthopaedic Association has issued guidance on the management of severe open lower limb fractures (BOAST 4).

British Orthopaedic Association (2009). BOAST 4: the management of severe open lower limb fractures. https://www.boa.ac.uk/wp-content/uploads/2014/12/BOAST-4.pdf

19. C. 72 hours or until definitive wound closure (whichever is sooner)

Antibiotics can be stopped once the wound is closed: 72 hours is the alternative but wounds should be covered (thus closed) by this time. The British Orthopaedic Association has issued guidance on the management of severe open lower limb fractures (BOAST 4).

British Orthopaedic Association (2009). BOAST 4: the management of severe open lower limb fractures. https://www.boa.ac.uk/wp-content/uploads/2014/12/BOAST-4.pdf

20. A. Acute stroke

NICE has issued clinical guidelines (CG92) and quality standards (QS3) on VTE. These detail the preventative measures against VTE for all adults on hospital admission.

National Institute for Health and Care Excellence (NICE) (2010). Venous thromboembolism: reducing the risk of venous thromboembolism (deep vein thrombosis and pulmonary embolism) in patients admitted to hospital. *NICE Guideline CG92*. https://www.nice.org.uk/guidance/cg92

National Institute for Health and Care Excellence (NICE) (2010). Venous thromboembolism prevention quality standard. *NICE Quality Standard QS3*. https://www.nice.org.uk/guidance/qs3

chapter
3

SPINAL TRAUMA

Questions

1. A 44-year-old electrician falls from a ladder and suffers an isolated L4 fracture. There is anterior wedging of the vertebral body with 40% loss of vertebral height. Which of these associated features would be an indication for operative stabilization?

Select the single most appropriate answer.

A. Injury to the posterior ligamentous complex on MRI
B. Kyphosis of 15°
C. Left leg radiculopathy since the injury
D. Middle column fracture
E. Retropulsion of a vertebral body fragment reducing the spinal canal by 35% with no neurological deficit

2. A 57-year-old woman falls from a stepladder and lands on her head suffering an isolated Anderson type II (Jefferson) C1 burst fracture. Which of the following is the maximum combined lateral displacement of the lateral masses on an open mouth radiograph or CT before it is deemed unstable?

Select the single most appropriate answer.

A. 2.9 mm
B. 4.9 mm
C. 6.9 mm
D. 8.9 mm
E. 10.9 mm

3. A 25-year-old male motorcyclist is involved in a crash. He has amnesia, a GCS of 14, and neck pain. He is appropriately resuscitated and immobilized using ATLS protocols. He is moving all four limbs and is haemodynamically stable with no other obvious injuries. His C-spine CT scan is reported as normal. What chance is there of a missed C-spine injury?

Select the single most appropriate answer.

A. 0.07%
B. 0.7%
C. 1.7%
D. 2.7%
E. 7%

4. A 26-year-old restrained male driver is involved in a high-speed car crash. He complains of back pain and is extricated from the vehicle with full spinal precautions. Plain radiographs and CT reveal an anterior column fracture of L1. He is haemodynamically stable with no other injuries. Examination reveals boggy tenderness around the thoracolumbar junction. Neurological examination is normal. Which of the following is the most appropriate next management step?

Select the single most appropriate answer.

A. Flexion and extension radiographs of the thoracolumbar spine
B. Long segment posterior stabilization
C. Mobilization in a brace
D. MRI
E. Repeat CT after mobilizing

5. Which of the following is the most important initial management step to minimize secondary damage following spinal cord injury?

Select the single most appropriate answer.

A. Administration of methylprednisolone
B. Administration of tirilazad mesylate
C. Maintenance of MAP over 70 mmHg
D. Maintenance of MAP over 90 mmHg
E. Surgical decompression and stabilization within 48 hours