David Ip

Orthopedic Traumatology – A Resident’s Guide

Second Edition
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Second Edition

With 205 Figures and 3 Tables
This book is dedicated to all those who are interested and involved in the care of patients suffering from orthopaedic trauma, especially the front-line workers.
Dr. David Ip is a fellow of various professional organizations, including the Royal College of Surgeons and the Hong Kong College of Orthopedic Surgeons, and is a member of the American Academy of Orthopedic Surgeons and the American Association of Academic Physiatrists, among many others, such as the International Association for the Study of Pain and various Gait Analysis societies. His biography is included in Marquis Who’s Who in Science & Engineering, Who’s Who in Medicine and Healthcare, Sterling’s Who’s Who in NY, and the International Who’s Who Historical Society. In his capacity as Director General (Asia) of the International Biographical Association of the UK and as Clinical Governor of the American Biographical Institute he has contributed significantly to peer-reviewed journal articles and has written several books on orthopedics, which have received positive reviews from the Royal College of Surgeons and the Journal of Bone and Joint Surgery. He is also the reviewer of selected orthopedic journals published in Europe, and holds honorary consultancy positions for various companies like the Lehrman Gerson group, Brand’s Institute, Medacorp, among many others.
The author and the publisher would like to take this opportunity to thank the medical community for the utmost warm welcome given to the first edition of this book. A second edition is deemed necessary not only because of the extreme popularity of the first edition such that the international stock of the book was sold out in less than a year, but also because, as mentioned in the first edition, orthopaedic traumatology is a rapidly expanding field.

In this second edition, some important chapters like those on computer-aided surgery and surgical navigation have been completely revised, as well as the chapter on fracture fixation principles, while many new chapters have been added to keep front-line workers in trauma abreast of the rapidly changing paradigm shift in fragility fracture management. That a much more positive attitude should be taken by orthopaedics with regard to their role in concomitant osteoporosis management is echoed by the recent policy statement of the AAOS, and is reflected in the contents of the “blue book” or official publication of the British Orthopaedic Association. Such changes come about thanks partly to the great efforts of leaders in this field such as Drs Gallacher and McLellan from Glasgow, who successfully pioneered the “Fragility Fracture Liaison Service”, which is now used in many general hospitals across Europe, as well as in parts of Asia. However, in order for a programme that tackles secondary prevention of hip fractures to be successful, there is a strong need for an evidence-based fracture hip protocol that incorporates the latest research findings in biophysics, neurophysiology, fall prevention, physiotherapy, gait analysis and orthopaedics. To this end, a new chapter on this subject has been added.
There is also a need for a brand new user-friendly “Fall Scale” that can be used by general practitioners, volunteers, community nurses, paramedics and other medical staff to monitor the patient’s progress after physiotherapy training to act as an early warning system in case of de-conditioning. To this end, the author has described a new fall scale known as the “Simplified Fall Scale”, which meets the requirements of being easy to perform in less than a minute, with no need for special equipment apart from a standard high-chair with arms, and it can easily be remembered and taught by staff with little orthopaedic experience, such as volunteer teams and family doctors who are not frequently exposed to orthopaedic fracture conditions.

Finally, as this book is mainly written for front-line workers, the author has deemed it necessary to include another new chapter on orthopaedic emergencies.

Lastly, the author wishes to thank again Professor Court-Brown, Edinburgh, and Professor John Wedge of the Toronto Hospital for Sick Children for their kindness in writing the forewords for the first edition of this book, which proved to be a major success. For those readers using this book in preparation for professional exams, I wish them the best of luck and happy reading!

David Ip

Hong Kong, November 2007
Doctor Ip is to be congratulated for writing such a useful book on orthopaedic trauma. This is a rapidly expanding field and many disciplines now treat fractures, dislocations and soft tissue injuries and their sequelae. There is a need for a book to help educate trainees in orthopaedic surgery, nursing, physiotherapy and rehabilitation medicine as well as medical students, and this book fulfils that need. It is succinct, but contains a great deal of information important to these and other paramedical disciplines.

There are 15 chapters dealing with all aspects of orthopaedic trauma and its management. It is to Doctor Ip’s credit that he has not forgotten the future of orthopaedic trauma, and there are chapters on minimally invasive and computer-aided surgery and fall prevention in the elderly. In addition, the book has chapters on high energy trauma, bone healing, the principles of fracture management and the management of different fractures.

The format is user-friendly and it will appeal to all paramedical disciplines, senior medical students and surgeons-in-training. I have no doubt that they will find it useful and I hope they enjoy reading it.

Charles Court-Brown, Edinburgh
David Ip has written a remarkable book for orthopaedic residents that reduces the complexity of modern traumatology to basic concepts, principles and guidelines, providing the learner with a practical approach to trauma management. Each of the 15 chapters easily stands alone and may be consumed in a single study session. The organisation of this concise treatise is consistent from chapter to chapter and has numerous “tips” and “pearls“, building on a sound conceptual framework.

This is not intended to be a technical manual or comprehensive textbook – the resident already has many of these to choose from – but rather a compendium of essential information to be enhanced by clinical experience and detailed literature review. More than 200 illustrations nicely complement the text, providing excellent examples of both common and less common serious injuries.

I believe this book meets the author’s very important objective of a reasonably brief, yet comprehensive, survey of trauma management that fulfils the resident’s need for core information. The chapters on normal and abnormal bone healing and on the principles of fracture fixation are particularly clear and informative.

My compliments to the author for writing a much-needed concise and excellent guide to trauma management.

John H. Wedge
Like its popular companion volume, *Orthopaedic Principles – A Resident’s Guide*, which was well received by the medical community, *Orthopaedic Traumatology – A Resident’s Guide* was written to stimulate interest in modern orthopaedic traumatology, which is a very dynamic and rapidly changing field. This book aims at a very wide readership. From the resident preparing for professional examinations, to the physical and occupational therapists and nurses involved in the daily care of fracture patients, since fractures form the bulk of emergency orthopaedic admissions in many major hospitals. Also, surgeons requiring re-certification as well as surgeons in developing or under-developed countries will find the volume useful in their daily practice. Finally, this book is structured in such a way as to facilitate review of the subject matter before board exams and quickens the process of information retrieval of both classic and recent references. Happy reading!

*David Ip*
Hong Kong, November 2005
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Ten Questions for Residents

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Introductory Comment

- This is a very short chapter
- It serves as a brainstorming session for our young surgeons-in-training, urging them to think about some critical issues relating to modern orthopaedic trauma
- Most of the answers to the 10 questions can be found in the ensuing 14 chapters of this book

1.1 High Energy Trauma: Are We Doing Enough to Keep It in Check?

- The study of the management of patients suffering from high energy poly-trauma is vital, since many of these are young patients in the prime of their life. High energy trauma is in fact the main cause of death in young people in many countries (leading cause of death in the <40-year-olds)
- Poor management can create significant morbidity and mortality. Prevention is always the best strategy. However, this can only be achieved by the concerted efforts of the legislators, vehicle engineers, highway architects, proper trauma triage, and development of trauma centres, as well as having good orthopaedic traumatologists
- The prevention and management of this problem will be discussed in Chap. 2

1.2 Medico-Legal Corner: Why Are Fractures Being Missed?

1.2.1 The Two Faces of a Fracture

- The commonest cause of missing a fracture is depending on only one X-ray view of human bones, which are essentially three-dimensional structures
- It is recommended that at least two X-ray views 90° to each other be taken for any anatomical region to be assessed
1.2.2 Other Causes of a Missed Fracture in the Stable Patient

- Bones with a complex shape frequently require more than two X-ray views for proper assessment of any fracture. A common example is the scaphoid fracture (Fig. 1.1)

- Fractures can be missed in bones that are obscured by other structures on the X-ray. An example is missing a fractured sacrum due to the anatomical details being obscured by bowel gas

- We may sometimes opt to perform more sophisticated investigations such as a computed tomography (CT) scan for more complex fractures like the acetabulum; even CT can miss the fracture if the plane of the fracture line lies in the same plane as the CT cut

- Some fractures simply do not reveal themselves in the acute X-ray film. These difficult cases can only be diagnosed given time either by serial X-rays, or special investigations such as bone scanning or MRI. Examples can be found in some stress fractures, which are discussed in Chap. 5

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Fig. 1.1 The scaphoid fracture was not noted preoperatively, as attention was drawn to the obviously fractured distal radius, until fluoroscopic screening in theatre in multiple planes
1.2.3 Reasons for Missing Fractures in the Poly-traumatised Patient

- Recent literature revealed that missing injuries including fractures is common even in this day and age, amounting to around 22%, and up to 75% of the missed injuries in a recent study were musculoskeletal (Brooks et al. 2004)
- This highlights the importance of repeated clinical examination in these frequently obtunded patients. The concept of tertiary survey was first emphasised by Enderson et al. in 1990, but in fact the concept originated from the ideas of Prof. Gissane
- In particular, missing cervical spine injuries can be devastating to both the surgeon and the patient. Any poly-traumatised patient coming to the accident service should be assumed to have a cervical spine injury until proven otherwise; and the cervical spine of the patient should be assumed unstable until proven otherwise. Poorly taken lateral views of the cervical spine is of little help and give a false sense of security; be liberal in the use of CT scanning to assess the cervical spine region. Having said that, do not miss concomitant spinal injury elsewhere, which can occur in up to 7% of cases

1.3 Why Does the Postoperative X-ray Not Always Look as Good as It Should?

- We often hear expressions from residents like: “I am positive the fracture was reduced intraoperatively, why is it that I have come up with a horrible looking postoperative X-ray?”

1.3.1 Answer: The Two Faces of a Fracture Reduction

- Just as looking at a bone with a suspected fracture using one X-ray view may miss the fracture, the same is true of an intraoperative fracture reduction
- The reduction or alignment may look perfect in one plane, but much displaced in another (Figs. 1.2, 1.3). Thus, to prevent any postopera-
tive surprises, it is essential to screen our intraoperative fracture reduction using at least two views, preferably 90° to each other.

1.4 Is There a Rigid Guideline for All Intra-articular Fracture Reductions?

- The likely answer is in the negative
- This is because the effect of articular incongruity on a joint varies depending on the articular cartilage thickness, the modulus of the articular cartilage, and the geometry of the joint, as well as its global congruity
- Example: greater leeway can be given to articular step-offs at the lateral tibial plateau, while very little compromise can be given to step-offs at the weight-bearing dome of the acetabulum

1.5 What Importance Do We Give to a Perfect-Looking Postoperative X-ray?

- In the past, patients and surgeons paid much attention to a good-looking X-ray. This is best exemplified by the traditional AO concept of perfect anatomical reduction and fixation of fractures
However, although perfect anatomical reduction is still required for intra-articular fractures (though not always predictive of outcome: see Sect. 1.7.1); the same perfect anatomical reduction and rigid fixation is not always needed or preferable in meta-diaphyseal fractures. This will be discussed in Chap. 4, when we discuss the concept of relative stability

1.6 Relative Stability (in Meta-diaphyseal Fractures): How Much Is Enough?

- The key here is the concept of elasticity or “elastic flexible fixation”
- This implies that displacement of the fracture ends under load must be reversible. Locked internal fixator technique (such as locking compression plate [LCP]) takes advantage of the elastic properties of metals, especially that of pure titanium, in fixing bones of limited strength like osteoporotic bones, by dint of the deformability of the implant, enabling the use of the elastic flexible fixation concept
- In short, this new concept of elasticity in fixation has the advantage that the implant–bone construct or anchorage is less likely to fail in the event of a single sudden high loading challenge to the construct or a traumatic event
- Exactly how much elasticity is enough for a given fracture is difficult to quantify, but this concept is very likely to be a move in the right direction, especially for the rising number of osteoporotic fractures. Osteoporotic fracture management will be discussed in detail in Chaps. 5 and 6

1.7 Radiological and Clinical Outcome: Do They Correlate?

- The fact that a good fracture outcome (of, say, intra-articular fractures) is not always predicted by a good- or perfect-looking postoperative X-ray is well known and reported in the literature
1.7.1 Reasons for the Discrepancy

- Diffuse injury to the cartilage can severely affect the outcome. This may not be reviewed by postoperative radiographs. This is because much of the injury to the cartilage was done at the time of the high energy injury.
- Articular step-offs of the articular cartilage are not an uncommon finding; despite a seemingly good postoperative X-ray, this relative incongruity can cause maldistribution of contact pressure on impact loading, especially in lower limb joints.
- Some recent studies have shown that using X-ray as the tool for assessing the degree of accuracy of articular fragment reconstruction in intra-articular fractures is rather low. (These studies have shown that frequently CT or arthroscopy is better in this respect.)
- Some other well-known factors that may complicate the issue of fracture outcome, despite a perfect-looking postoperative X-ray include: worker’s compensation issues and psychological make-up of the patient. These issues will be brought up and discussed in detail in Chap. 10.
- Using intra-articular fractures as an example, there are many factors that determine outcome besides mere articular surface reconstruction. According to the ideas of Joseph Schatzker, the important factors include:
  - Correction of meta- and diaphyseal deformity
  - Restoration of joint stability
  - Restoration of range of motion (ROM)

1.8 Soft Tissue Injury in a Fracture Patient: Does It Matter?

- Assessment and documentation of soft tissue injury is so important that we often hear the common saying: “fractures are essentially soft tissue injuries in which the bone happens to break”
- The degree of soft tissue injury affects the fracture in many ways as the following discussion will show.
1.8.1 Importance of Assessment of Soft Tissues in Fracture Patients

Assessment is important because:

- Nature of soft tissue injury affects the timing of surgery. This is especially true for regions with a thinner soft tissue envelope such as the tibia, the ankle, etc.
- Soft tissue complications can affect healing of fractures. Example: Court-Brown and McQueen of Edinburgh demonstrated delay in healing of tibial fractures if the patient developed compartment syndrome.
- Neurovascular injuries are important as their presence affects the decision-making process of the orthopaedist, such as Holstein fracture with radial nerve palsy. Occasional cases of acute ischaemia also need early revascularisation.
- In open fractures, the degree of soft tissue injury affects the healing as the vascularity is affected to different extents. This can be seen by the different healing times of open fractures with different Gustilo's grades. This will be discussed in Chap. 5.
- Management of soft tissue injuries in high energy trauma and soft tissue coverage problems will be dealt with in Chap. 2.

1.9 Computer-Aided Surgery: Are We on the Right Track?

Substantiating evidence to say that we are on the right track on this score includes:

- The use of computer guidance in the performance of highly accurate tasks is not new. This is already a well-developed field in neurosurgery: e.g. use of stereotactic surgery in tackling strategic brain lesions. The same is true of using this new technological know-how in for instance fixing pelvic/acetabular fractures, like administration of iliosacral screws where the margin of safety is small.
- There has been a general move towards minimally invasive techniques to minimise surgical trauma to the patient in all fields of surgery in recent decades. Techniques like virtual fluoroscopy...
(Fig. 1.4) can aid performance in this respect. As an example, the starting point for intramedullary (IM) nail insertion can be identified by virtual fluoroscopy, via the trajectory “look-ahead” feature, which can be used to align the drill guide with the femoral canal in two planes in femoral nailing.

- Other advantages: good teaching tool for future surgical residents, less exposure to radiation since stored images can be employed to provide surgical guidance and can be readily updated after intraoperative fracture reduction.

- We often associate CT-guided navigation and virtual fluoroscopy when we talk about computer-aided surgery. The scope with which the computer can aid the orthopaedic surgeon is much larger, for example:

  - The newly developed Taylor spatial frame: although it resembles an Ilizarov, on entering the correct data into the computer before correction of deformity, simultaneous correction in all planes of freedom can now be achieved for the first time in orthopaedic surgery (cf. if the Ilizarov construct is used, the planes of deformity such as translation and rotation are corrected sequentially).
The computer is also indispensable in many other fields of orthopaedics, such as analysing not only two-dimensional but also the more recently developed three-dimensional gait analysis results to help plan surgery.

The possible future use of robotics is also highly dependent on computer technology.

1.10 Fragility Fractures Rising (Exponentially): What Can Orthopaedists Do?

- There is an exponential increase in incidence of hip and other fragility fractures (Fig. 1.5) as shown by recent epidemiological data.
- We expect a soaring incidence of fractured hips, particularly in countries with an aging population.
- The best way to circumvent this vast problem is still prevention. This includes both primary and secondary prevention. To this end, the

![Fig. 1.5](Image) It should be noted that the presence of a fragility fracture is predictive of others. This patient with a fractured distal femur also had bilateral hip fractures in the past.
administration of a fall prevention programme is vitally important, as well as treatment and prophylaxis of osteoporosis

- It is surprising to note that large scale primary and secondary fall prevention programmes may not be the norm, even in well developed countries. This underscores the urgency of the problem, which will be dealt with in Chap. 15

**General Bibliography**


**Selected Bibliography of Journal Articles**

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2.1 Why Study High Energy Trauma?

- High energy trauma is a major cause of mortality among young citizens of modern society
- One recent study in US revealed that injury is the leading cause of death under the age of 40. The total cost of injury to society approaches $100 billion a year

2.2 Trauma Triage and Scores

2.2.1 What Is Triage?

- Triage comes from a French word meaning “to sort”
- It had its roots initially during wartime in Napoleonic times when they sorted out those less wounded soldiers who could go back into battle
- In modern traumatology, we do the opposite, i.e. sort out those severely injured persons who need the support of a trauma centre

2.2.2 Evolution of Civilian Triage over the Years

- At first, the aim of pre-hospital triage mainly focused on identification of trauma victims who would benefit from the care of specialised trauma centres (see American College of Surgeons [ACS] guidelines to be discussed)
- It soon became obvious that optimal care should also be provided to those victims with somewhat lesser injuries. This forms the concept of “inclusive” care

2.2.3 Main Types of Trauma Triage

- Pre-hospital triage in the field
- Triage of patients after hospital arrival
- Triage during disasters
- Triage during wartime (wartime triage and triage in disasters will not be discussed in this book)
2.2.4 Which Trauma Score to Use?
- There are many different trauma scoring systems available. But it will be advisable only to adhere to those that are user-friendly, do not involve complex calculations, and have a reasonable degree of sensitivity and specificity.

2.2.5 Sensitivity and Specificity
- Sensitivity of a trauma score: the higher the sensitivity, the higher the likelihood of detecting the really severely traumatised patients.
- Specificity of a trauma score: the higher the specificity, the lesser the likelihood of missing the really severely traumatised patients.
- Scores with low sensitivity risk the chance of “over-triage”.
- Scores with low specificity risk the chance of “under-triage”.

2.2.6 The Spectrum of Trauma Scores
- There are over 50 scoring systems that have been developed for triage and research over the years and yet the task of separating the stable from the unstable patients is still difficult.
- Detailed description of each of the scores will not be included here.

2.2.7 Which System to Use?
- Besides issues of sensitivity and specificity, the exact trauma score to be used depends on the clinical situation at hand. It is thus difficult to comment on the best trauma scoring system.
- For example, the director of an Intensive Care unit may be more interested in scores that can predict the likelihood of survival of his patients, but the same may not be the focus of concern of the cost-conscious hospital administrator.

2.3 Mortality in High Energy Trauma

2.3.1 Timing and Mortality
- There are three main phases:
  - Mortality before arrival in hospital: from major destructive injury of organ system(s).
2 High Energy Trauma Management

— Early day 1 mortality: common causes include severe head injury, hypovolaemia and hypoxia
— Late mortality: mostly from multiple organ dysfunction (MODS), include entities like adult respiratory distress (ARDS) and disseminated intravascular coagulation (DIC)

2.3.2 Key Point
- Haemorrhage is the major cause of death in the first 3 h (the first 3 h are sometimes called the Golden Hours)

2.3.3 Causes of Pre-hospital Mortality
- These occur shortly after the injury and are most likely due to severe brain injury or disruptions of the heart or the large vessels
- Severe injuries like these can cause death within minutes

2.3.4 Ways to Prevent Pre-hospital Mortality
- Road safety measures, especially on highways
- Law enforcement, e.g. concerning drink-driving
- Better vehicle design
- Swift transport of trauma victims, including helicopters
- Triage to Trauma Centre
- Pre-hospital trauma scoring
- Pre-hospital trauma life support

2.3.5 Importance of Pre-hospital Triage
- As many as 50% of trauma deaths from severe trauma occur prior to hospitalisation (reported in literature from US)
- A well-developed system of early notification and rapid transport (including helicopter transport) is necessary, especially if the accident occurs in rural areas or less accessible areas

2.3.6 Elements of Pre-hospital Triage
- There are three main aspects involved in pre-hospital trauma triage:
  — Physiology parameters
  — Anatomical parameters
Mechanism of injury
(Also of importance may be age and associated medical conditions)

2.3.7 ACS-Recommended Guidelines for Pre-hospital Triage

The ACS guidelines (adapted from American College of Surgeons Committee on Trauma, 1999):

- Physiological parameters:
  - Glasgow Coma Scale (GCS) < 14
  - Systolic blood pressure (SBP) < 90
  - Respiratory rate (RR) < 10 or > 29
  - Revised trauma score < 11

(Admit to trauma centre if any one of above present)

- Anatomical parameters:
  - Flail chest
  - ≥ Two proximal long bone fractures
  - Penetrating injuries to head/neck/trunk or proximal extremity
  - Fractured pelvis
  - Amputation proximal to ankle and wrist
  - Combined burns and trauma

(If any of above present, admit to trauma centre)

- Injury mechanism parameters:
  - Death occurring in same passenger compartment of vehicle or major vehicle deformity
  - Time of extrication > 20 min
  - Fall from > 20 feet (6 m)
  - Ejected from vehicle or rolled over or pedestrian thrown away by vehicle

(If any of above present, contact control and assess need for trauma centre)

- Assessment of age and associated conditions:
  - Age < 5 or > 55
  - Pregnancy
  - Cardiopulmonary disorders
  - Immunosuppressed/insulin-dependent diabetes mellitus (IDDM)/ morbid obesity, etc.
2.4 Why Triage to Trauma Centres?

2.4.1 Need for Organised Trauma Centres
- A paper by Trunkey (West et al. 1979) serves as an excellent reference on systems of trauma care. It compares an organised system of trauma delivery in San Francisco with a random arrangement in the LA area of Orange County in USA. Significantly more patients accessed appropriate care in San Francisco.
- It should be noted, however, that only an estimated 25% of the US population currently lives in regions with a designated trauma centre.

2.4.2 Mortality Reduction with Trauma Centre Development
- It has been shown that the setting up of trauma centres can reduce mortality of severely injured trauma victims.
- Literature reported that overall roughly 5–10% of trauma patients are in need of proper pre-hospital triage to these trauma centres.
- The idea of pre-hospital triage of severely injured patients to trauma centres has now been adopted in many countries.

2.5 Preventing Mortality in the First 24 Hours
- Advanced trauma life support (ATLS) protocol
- Emergency surgery
- End-points of resuscitation
- Trauma scoring after hospital arrival and definition of severe trauma
- Concept of damage control and damage control orthopaedics