Clinical Review of Vascular Trauma

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ISBN 978-3-642-39099-9 ISBN 978-3-642-39100-2 (eBook)
DOI 10.1007/978-3-642-39100-2
Springer Heidelberg New York Dordrecht London

Library of Congress Control Number: 2013950485

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Dedicated to all of our trauma patients – past, present, and future

Foreword

The American Heritage Dictionary of the English Language defines evolution as a gradual process in which something changes into a significantly different, especially more complex or more sophisticated, form. The same dictionary defines revolution in several ways. For this foreword, I would use an assuredly momentous change in any situation. I believe these two definitions apply to the last 10 years in vascular injuries. What has caused this evolution/revolution? Clearly, there are many issues. To a great extent, it is the vendors who provide endovascular stents in the rapid evolution from the original stents for the thoracic aorta to almost any vessel in the human body. An equally important concept was when surgeons stepped forward and learned the techniques of interventional radiologists. Another evolutionary concept was the hybrid operating room where surgery could be carried out as well as placement of endovascular prosthetics. This is an extremely important concept because we are just now developing management protocols in patients with vascular injuries. There are some significant problems. When does the surgeon make a decision to locate the injury with open surgery, tomography, or arterial visualization with injected contrast agents into the vascular system? Alternatively, if an injury can be demonstrated, it may be simpler to control the bleeding blood vessel (artery or vein) by balloon technology. Protocols and treatment algorithms will help as more experience is gained over the next few years. It will be particularly important to define our limitations particularly in some vascular areas. The use of stents may not be the best for intracranial acute vascular injuries.

This book *Clinical Review of Vascular Trauma* is one of the first of many to take on the challenge of defining the problems today, and in their first part they address vascular surgery essentials. This part outlines general vascular principles such as the use of vascular diagnostics, scoring systems, and the hematologic perspectives that includes a discussion on anticoagulation, vascular trauma resuscitation, and hemostatic monitoring. The subject of anticoagulation is extremely important. From my perception, anticoagulation contributes more to morbidity than any one other single entity. Other chapters in vascular surgery essentials include an overview of vascular trauma, a chapter on the mangled extremity, and another chapter by Burgess on fasciotomy. These are important due to recent activities in the Middle East as well as the bombing in Boston. The chapter on surgical critical care is particularly important because I believe the vascular surgeon must be involved in critical care decisions. Very few interventional radiologists care about

surgical critical care and delegate it to other specialties. There must be surgical input!

The rest of the book is dedicated to the various regions of the anatomy, and the second part is on cerebral vascular and upper extremity injuries. This part is particularly important because of the limitations of some of the bony canals and the skull base.

The third part is on the chest which is the area where endovascular surgery had its beginnings. The fourth part is on abdominal vascular injuries and focuses on the abdominal aorta and the branches. I think there is particular merit in having a separate subsection of the IVC and other major veins. During my surgical career I have gained a major respect for large veins. I have successfully repaired avulsion of the left hepatic vein in two patients and avulsion of the right hepatic vein in two patients with one survivor.

The pelvis is the fifth part and this can be very important to the patient with grade IV and V pelvic fractures.

The sixth part covers the lower extremity and this particular anatomical region is evolving rapidly. I am also pleased to see a special consideration of military injuries, pediatric and vascular trauma, neurologic injuries, and the use of shunts particularly in far forward military situations. This concept could be used in rural areas, particularly farm country where vascular injuries are common but the surgeons are not there to care for them. Why not teach the same concepts of shunts to the rural general surgeon?

I believe that modern vascular trauma surgery is an exciting and worthwhile venture. Hopefully, we will be able to develop treatment protocols based on experience that would tell us whether to open a chest or abdomen to gain control or we can do it with balloons above or below the injury or directly in the injured artery or vein.

Portland, OR, USA Donald Trunkey, MD

Preface

Caring for people who are afflicted by trauma is an honor and a privilege. These people who come into our trauma bays are exactly that, people; hence in trauma, there is no such thing as a "vascular" patient, an "orthopedic" patient, or a "plastics" patient. There is but the patient.

As surgeons we certainly strive to provide excellent, holistic care for our patients but sometimes the silo nature of our healthcare systems hinders instead of helps. Specialist services have taken over for the general surgeon in many areas with a noble aim: to provide expert care by dedicated surgeons. However, this double-edged sword can simultaneously prevent us from engaging as we should with other disciplines, and it is this issue of communication that can lead to devastating consequences for our patients. This book was inspired by a patient who sustained a gunshot wound to the abdomen resulting in a bowel and iliac injury. After trauma surgery stabilized the patient, vascular surgery was consulted to fix the iliac artery injury. They opted to use vein graft which got infected and disintegrated 7 days later, leading to frank hemorrhage and near death for our patient. As per the "vascular" literature, the choice of conduit was correct: a contaminated field meant vein graft to reduce the infection risk. However, recent "trauma" literature from the Iraq and Afghanistan wars advocated for the use of prosthetic graft in a contaminated field to avoid the complication we faced with our patient. The correct approach here would have been for both the vascular and trauma teams to have been aware of each other's literature so an informed, best-practice decision could have been made for our patient. This text is an attempt to bring together evidence from multiple fields that are involved in the care of trauma patients with vascular pathology.

This book is broken down by vessel injury so it may serve as a reference for any orthopedic, vascular, trauma, acute care, plastics, or cardiothoracic surgeon during that 2 AM trauma call. Every part has been meticulously reviewed by surgeons from various disciplines so that chapters provide a consensus between the disciplines. Our senior editors include a professor of trauma and acute care surgery (Dr. Holcomb), a professor of vascular surgery (Dr. Freischlag), and a professor of orthopedic surgery (Dr. Burgess) along with a vascular fellow (Dr. Desai) and myself (Dr. Dua) a general surgery resident. We are an example of the team that would come to the trauma bay to take care of a vascular trauma patient, and all viewpoints are an essential part of this book as they should be an essential part of patient care.

This text includes dedicated chapters on the mangled extremity and fasciotomy, written by Dr. Burgess, an orthopedic surgeon. In our medical system, mangled extremities are managed by the trauma or vascular surgery team. Today, barely any house staff have any orthopedic rotations or basic clinical experience in the diagnosis of high-energy musculoskeletal injury, especially when combined with significant vascular injury. Therefore, a text of this nature brings the orthopedic viewpoint to the forefront so it can be a consideration during a trauma call by all members of the surgery teams involved.

The overall mission of this book is to optimize the care of trauma patients using a multidisciplinary approach.

Houston, TX, USA Anahita Dua, MD

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Abbreviations

AAST	American Association for the Surgery of Trauma
ABC	Airway, breathing, and circulation
ABI	Ankle-brachial index
ACS	American College of Surgeons
ADP	Adenosine diphosphate
AIS	Abbreviated injury score
AP	Anterior-posterior
APTT	Activated partial thromboplastin time
ASA	Aspirin
AT	Anterior tibial
ATLS	Advanced trauma life support
AV	Arteriovenous
AVF	Arteriovenous fistula
BAAI	Blunt abdominal aortic injury
BAI	Blunt aortic injury
BCI	Blunt cardiac injury
BCVI	Blunt cerebrovascular injury
BPM	Beats per minute
BRAI	Blunt renal artery injury
BTAI	Blunt thoracic aortic injury
CABG	Coronary artery bypass graft
CAD	Coronary artery disease
CAG	Coronary angiography
CCA	Common carotid artery
CCD	Charge-coupled device
CFA	Common femoral artery
CFD	Color flow duplex
CKD	Chronic kidney disease
CNS	Central nervous system
COT	Committee on Trauma
CPN	Common peroneal nerve
CPU	Central processing unit
CT	Computed tomography
CTA	Computed tomographic angiography
DBP	Diastolic blood pressure
DIC	Disseminated intravascular coagulation
DP	Dorsalis pedis

DSA	Digital subtraction angiography
DUS	Duplex ultrasonography
DVT	Deep vein thrombosis
EAST	Eastern Association for the Surgery of Trauma
ECA	External carotid artery
ECMO	Extracorporeal membrane oxygenation
ECRB	Extensor carpi radialis brevis
ECRL	Extensor carpi radialis longus
ED	Emergency department
ePTFE	Expanded polytetrafluoroethylene
FAST	Focused assessment with sonography in trauma
FDA	Food and Drug Administration
FFP	Fresh frozen plasma
FWB	Fresh whole blood
FXIII	Factor XIII
GCS	Glasgow coma score
GDA	Gastroduodenal artery
GONR	Graphene oxide nanoribbon
GSW	Gunshot wound
GWOT	Global war on terror
HES	Hydroxyethyl starch
HOCM	High-osmolar contrast media
HR	Heart rate
HU	Hounsfield unit
IAOB	Intra-aortic occlusion balloon
IAVI	Intra-abdominal venous injury
ICA	Internal carotid artery
ICU	Intensive care unit
IFU	Instructions for use
IMA	Inferior mesenteric artery
IMV	Inferior mesenteric vein
INR	International normalized ratio
IOCM	Iso-osmolar contrast media
ISS	Injury severity score
IV	Intravenous
IVC	Inferior vena cava
IVU	Intravenous urography
KE	Kinetic energy
KUB	Kidney, ureters, and bladder
LMWH	Low-molecular-weight heparin
LSA	Left subclavian artery
LTA	Light transmission aggregometry
Ly	Clot lysis
M	Mass
MA	Maximum amplitude
MAI	Minimal aortic injury
MDCT	Multidetector row computed tomography
MESS	Mangled extremity severity score

MRA	Magnetic resonance angiography
MRI	Magnetic resonance imaging
MT	Massive transfusion
MTP	Massive transfusion protocol
MVC	Motor vehicle collision
NaCl	Sodium chloride
NAP	Nerve action potential
NBCA	N-butyl cyanoacrylate
NPO	Nil per os
NTDB	National Trauma Data Bank
OIS	Organ injury scale
PCI	Percutaneous coronary intervention
PFA	Profunda femoral artery
PLT	Platelet
POSSUM	Physiological and operative severity score for the enumeration of mortality and morbidity
PRBC	Packed red blood cells
PRN	As needed
PT	Posterior tibial
PT	Prothrombin time
PTFE	Polytetrafluoroethylene
PV	Portal vein
PVA	Polyvinyl alcohol
R	Reaction time
RBC	Red blood cell
RNA	Ribonucleic acid
ROTEM	Rotational thromboelastometry
RR	Respiratory rate
RT	Resuscitative thoracotomy
RTS	Revised trauma score
SBP	Systolic blood pressure
SFA	Superficial femoral artery
SMA	Superior mesenteric artery
SMV	Superior mesenteric vein
T	Temperature
TAG	Thoracic aortic graft
TAVI	Transfemoral aortic valve implantation
TEE	Transesophageal echocardiography
TEG	Thromboelastography
TEP	Trauma exsanguination protocol
TEVAR	Thoracic endovascular aneurysm repair
TF	Tissue factor
TIA	Transient ischemic attack
tPA	Tissue plasminogen activator
TPN	Total parenteral nutrition
TPT	Tibioperoneal trunk
TRA	Tibiopedal retrograde access
TRISS	Trauma and injury severity score

TTE	Transthoracic echocardiography
US	Ultrasonography
V	Velocity
VAC	Vacuum-assisted closure
VAI	Vertebral artery injury
VATS	Video-assisted thoracoscopic surgery
VHA	Viscoelastic hemostatic assay
VTE	Venous thromboembolism
vWF	von Willebrand factor
WTA	Western Trauma Association