BLAST INJURIES

Essay

Submitted for partial fulfillment of Master
Degree in General Surgery by

Mohammed Issa Mohammed Saleh
(M.B.B.CH.)

Supervised by

Prof. Dr. Reda Abd El Tawab Khalil Essa
Professor of General Surgery
Faculty of medicine
Ain shams university

Dr. Tarek Youssef Ahmed
Lecturer of General surgery
Faculty of medicine
Ain shams university

Dr. Youhanna Shohdy Shafik
Lecturer of General surgery
Faculty of medicine
Ain shams university

Faculty of medicine
Ain shams university
2014

بسم الله الرحمن الرحيم

وقل رب زدني علما

من الآية 114 من سورة طه

Acknowledgement

First and forever, praises and thanks be to **ALLAH**, the most merciful for assisting and directed me to the right way.

My sincere appreciation to **Prof. Dr. Reda Abd El Tawab Khalil Essa,** Professor of General Surgery, Faculty of medicine, Ain shams university, for suggesting and giving me the confidence and support to complete this work. I am very grateful and thankful for the time and effort he gave to make this essay possible.

Special thanks and deepest gratitude to **Dr. Tarek Youssef Ahmed** and **Dr. Youhanna Shohdy Shafik,** Lecturers of General surgery, Faculty of medicine, Ain shams university, for their supervision, valuable advice and encouragement during this work.

My sincere gratitude to **my father**, **my mother**, **my fiancée**, and **my family** for being there for me when things were complicated and for their support during the course of my study.

Mohammed Issa Saleh

List of Contents

List of Tables

List of Figures

List of Abbreviations

ABI	Ankle brachial index
AGE	Arterial gas embolism
APM	Anti-personnel mines
ARDS	Adult respiratory distress syndrome
ARS	Acute radiation syndrome
cGy	Centigray (SI unit of absorbed radiation)
CNS	Central nervous system
CPP	Capillary perfusion pressure
CPR	Cardiopulmonary resuscitation
CSFs	Colony-stimulating factors
CTA	Computed tomography angiography
DCOS	Damage-control orthopedic surgery
DIME	Dense inert metal explosives
DPL	Diagnostic peritoneal lavage
DVT	Deep vein thrombosis
ED	Emergency department
EMP	Electromagnetic pulse
FiO_2	Fraction of inspired oxygen
Gy	Gray (SI unit of absorbed radiation)
HE	High-order explosives
HFS-98	Hannover Fracture Scale-98
ICP	Intracompartmental pressure
IED	Improvised explosive device
kPa	Kilopascal

LE	Low-order explosives
MAD	Mean arterial pressure
MESS	Mangled Extremity Severity Score
NISSSA	Nerve Injury, Ischemia, Soft-Tissue Injury, Skeletal Injury, Shock, and Age of Patient Score
PaO_2	Partial pressure of oxygen in arterial blood
PBI	Pulmonary blast injury
PETN	Pentaerythritol tetranitrate
PR	Per rectum
PSI	Pounds per square inch
PTFE	Polytetrafluoroethylene
RDD	Radiologic dispersal device
SRD	Simple radiologic device
TATP	Triacetone triperoxide
TBI	Traumatic brain injury
TBSA	Total body surface area
TNT	Trinitrotoluene
UXO	unexploded ordnance

Introduction

A blast injury is a complex type of physical trauma resulting from direct or indirect exposure to an explosion. ***(Stuhmiller, 2010)***

Explosions can be caused by various events: Mechanical (Exploding pressure cooker), Chemical (conventional military-type explosion transforming a chemical compound – solid or liquid – into a large quantity of gas in an exothermic reaction, as seen in bombs, shells, mines), and Nuclear (fission or fusion device, atomic and hydrogen bombs). ***(Giannou et al., 2013)***

With almost daily news reports of explosions somewhere in the world, we are constantly reminded that explosion-related injuries can occur unexpectedly in both military and civilian populations. Because of the increased incidence of explosion-induced injuries, many physicians have first-hand experience with treating blast-injured casualties, and their insights, gained at a dear price, have led to improvements in care. The experience is worldwide and a consolidation of lessons learned would be invaluable. ***(Elsayed and Gorbunov, 2008)***

The explosive pressure accompanying the bursting of bombs or shells ruptures their casing and imparts a high velocity to the fragments. In addition, all explosions are accompanied by a complex blast wave composed of a blast pressure wave (dynamic overpressure) and the mass movement of air (blast wind). Like sound waves, blast pressure waves flow over and around an obstruction and affect anyone sheltering behind a wall or in a trench. A mass movement of air from the rapid expansion of gases at the center of the explosion displaces air at supersonic speed. This results in injury patterns ranging from traumatic amputation to total body disruption. When a blast pressure wave hits the body, the force of the impact sets up a series of stress waves that are capable of internal injury, particularly at air-fluid interfaces. Thus, injury to the ear, lungs, heart and, to a lesser extent, the gastrointestinal tract is notable. ***(Rashid, 2008)***

Primary, secondary, tertiary, and quaternary (Miscellaneous) injuries are the main four categories of blast injuries and these injuries have the capability to cause multisystem & life-threatening injuries in single or multiple victims simultaneously. These types present complex triage, diagnostic & management challenges. ***(Champion et al., 2009)***

Aim of Study

This work aims to evaluate proper ways to assess & manage patients with blast injuries to decrease their morbidity & mortality.

Chapter 1

Understanding The Blast

❖ Short History of Explosions:

The evolution of warfare has in certain respects largely been based on such technological developments that have engendered a wide variety of tactical combat situations and greatly affected the numbers of casualties and the types of wounds incurred.

Advances in the technology of modern high-order explosives (HE) and especially their delivery systems constitute one of the major factors that allow combatants to overcome more readily the "natural inhibition" against killing fellow human beings.

These developments have given rise to an enormous variety of combat scenarios from massive artillery and aerial bombardment of urban areas to the widespread use of landmines, the "perfect" remote and indiscriminate weapons that do not even require the perpetrator to pull a trigger.

Practically speaking, the result of this evolution has been the change in the preponderant wounding mechanism in the last 100 years from bullets to fragments or "shrapnel", which now cause up to 80 % of the injuries seen in wars between classical armies.

Fragments are the result of various explosive mechanisms and systems: aerial bombs, artillery or mortar shells; rocket-propelled and hand grenades; landmines and improvised explosive devices.

However, in addition to the production of fragments, explosive devices also have a primary blast effect that causes lesions with particular characteristics. ***(Giannou et al., 2013)***

- **Types of Blasts:**

In general, explosives fall into three major categories: chemical, mechanical, and nuclear. ***(Elsayed and Gorbunov, 2008)***

A) Chemical Explosions

Chemical explosives are the category most commonly used in conventional explosions and categorized as either low-order explosives (LE) or high-order explosives (HE). Low-order explosives release energy through a process called deflagration, which occurs at subsonic speeds, and is essentially a "burning" of the material. High-order explosive detonations result in the rapid transformation of the explosive material into a highly pressurized gas, which releases energy at supersonic speeds. ***(Elsayed and Gorbunov, 2008)***

- **High Order Explosives:**

HE are chemical materials that have an extremely high reaction rate. This reaction is often called a detonation (Table 1). High explosives are further categorized as primary and secondary high explosives. The primary-high explosive is very sensitive, can be detonated very easily, and generally is used only in primary and electrical detonators. Secondary high explosives are less sensitive, require a high-energy shock wave to achieve detonation, and are generally safer to handle. ***(Stewart, 2006)***

Table 1: Examples of High-Order Explosives. ***(Stewart, 2006)***

• Nitroglycerine • Dynamite • C-4 • Picric acid • Semtex • Dynamite (A mixture of diatomaceous earth and nitroglycerin patented by Alfred Nobel in 1867) • Ammonium nitrate-fuel oil (ANFO) mixture • TNT (Trinitrotoluene) • PETN (Pentaerythritol tetranitrate) • TATP (triacetone triperoxide)

HE exert their destruction by several mechanisms: 1) the blast pressure wave, 2) fragmentation, 3) blast wind, 4) incendiary thermal effect, 5) secondary blast pressure, and 6) ground and water shocks for explosions that occur under ground or water. Fragmentation effect occurs from projectiles that are either included within the container, projectiles that are created by the destruction of the container itself, or from those propelled objects from the surrounding environment and target. The motion of air generated by the blast waves creates blast wind. Secondary blast pressure effects result from the reflection of blast waves off surfaces, magnifying their effect, especially in enclosed spaces. Because ground and water are relatively non-compressible media, underground and underwater explosions transfer