

BLAST WAVE INJURIES

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CONTENTS

- Introduction -----	1
- Aim -----	3
- Physical Aspects Of Blast -----	4
- Pathogenesis of blast -----	12
- Pathology of Blast -----	15
- Clinical Presentation -----	32
- Protective Measures -----	41
- A Review Of Some Common Bomb Explosions.-----	44
- Treatment Of Blast Injuries -----	57
- Conclusion -----	81
- Summary -----	84
- References -----	87



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Bahaa

Introduction

INTRODUCTION

Blast injuries were described in the early 1920's. Some experience with the syndrome was gained by the Allies and the Germans in World War II. Apart from total war, injuries due to blast seem an inescapable fact of life, reflecting upon the failure of men to live in peaceful harmony together. These injuries now occur in all parts of the world. They occur because there are large numbers of the explosives available for the use of any fraction or group that decides to attempt to settle its differences with other groups by force of arms. Thus, explosives have become an increasingly popular terrorist weapon used by extremist groups.

The last few decades have seen a horrifying increase in violence involving explosives and of terrorism among civilian populations.

Among the great numbers of blast-induced violence, in civilians, explosions in overcrowded public spaces for terrifying purposes is the best example. Mentioned in this Essay was a terrorist bomb attack on the central railway station of Bologna, Italy, 1980.

On the other hand, injuries due to blast may occur accidentally. This is well apparent in situations where explosive substances are major components of certain industries e.g. Weapons manufacture. A recent recorded catastrophe was the explosion that happened in a military factory in Egypt 1984.

The more popular underground gas-pipes for home or industrial usage may be an additional hazardous condition. If leakage of this gas occurs in an inflammable event, serious blast injuries will occur. Many other examples are present.

Immersion-blast on the contrary although less frequent than air-blast, yet it can occur.

Personnel working in a pressurized atmosphere underwater e.g. in digging tunnels and clearance divers are the immediate victims if underwater explosion takes place.

From the foregoing it appears that blast injuries are common civilian accidents. Actually, 'peace time' is perhaps an inaccurate description of the situation in which society now exists .

Among the physical factors responsible for injury following an explosion, direct exposure to overpressure is the one dealt with in this Essay.

Aim

Aim of the Essay

Today any surgeon may suddenly be called upon to treat a patient or several patients injured by blast. Thus awareness of the nature of blast injuries, mechanism and pathology of injury is the aim of this Essay.

Physical Aspects Of Blast

Definition

The term blast injury designates the disruptive effects of the sudden changes in pressure that result from an explosion (W.A.D. Anderson and Joh M. Kissane 1977)

Physics of blast

Blast should be divided into two great varieties : air-transmitted blast and water-transmitted blast .

Physical aspects of air-transmitted blast

There are three components of the compound blast wave in air :

1.- Positive wave

The blast wave starts with a single pulse of increased pressure lasting a few milliseconds; this layer of compressed air has an extremely sharp front less than one thousandth of an inch thick in which the pressure rises almost instantaneously to peak levels (Fig.1).

It then falls rapidly to reach a minimum pressure which is less than the previous atmospheric pressure . The duration of the pulse depends on the type of explosive and the distance from the center of the explosion. The duration of the pulse is important, for it represents the time an object in the path of a shock wave is subjected to the pressure squeeze. For TNT, an overpressure of 100 lbf / in^2 may be associated with a duration of 2 ms for a 25 Kg charge and 10 ms for

200 Kg charge. The velocity of the blast shock wave in air may be as high as 300 m/s but it soon falls to the speed of sound within a variable distance depending upon the amount and composition of the explosive .

The maximum pressure of the blast wave immediately adjacent to the explosive charge is extremely high. Thereafter the pressure falls off as the wave moves away from the source of the explosion. For example with TNT a 30 Kg charge produces 100 lbf / in² at 5m and 6 lbf / in² at 15m , whereas a 50Kg charge produces 200 lbf / in² at 5 m and 10 lbf / in² at 15m .

The incident pressure is the pressure level at 90° to the direction of the travel of the blast shock front. The blast pressure waves flow over and around an obstruction, like a wall, and affect some one sheltering behind it (Fig.2). The reflected pressure is the rapid build up of pressure that occurs when a shock front strikes a flat surface in its line of travel, a person standing near a wall facing an explosion would be exposed to both incident and reflected pressure.

(M.S. Owen - Smith 1981)

2- Negative Phase

The negative pressure or suction component of the blast wave is much less than the positive pressure phase and can never be greater than 15 lbf / in² .

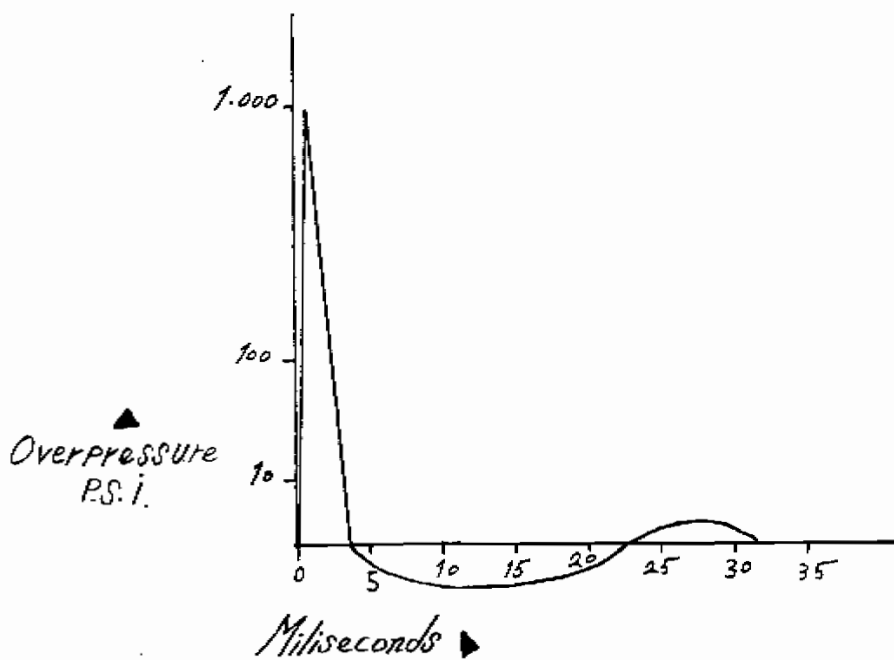


Fig.1 Form of a blast Wave

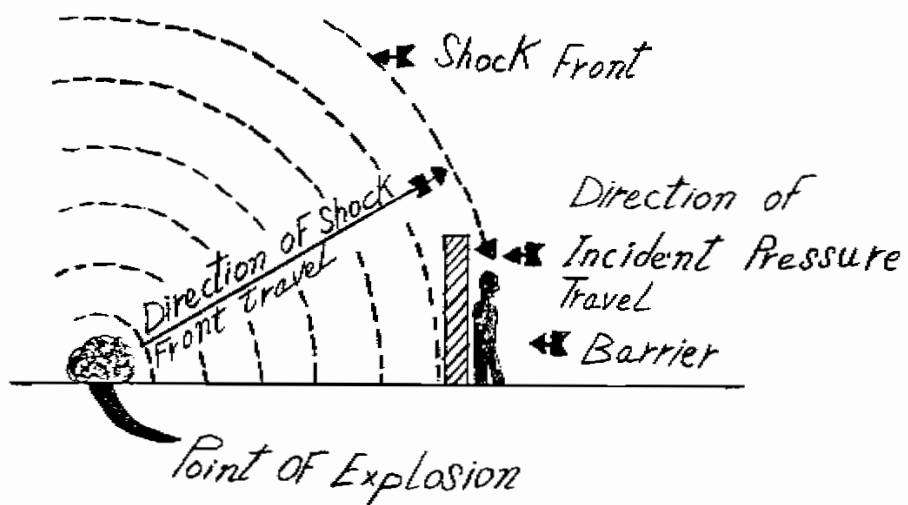


Fig. 2 Diagram of an explosion showing a direction of propagation of a blast wave and how the incident pressure will affect a subject sheltering behind a wall

it follows immediately after the positive wave but lasts about ten times as long .

- Mass movement of air

The rapidly expanding gases from an explosion displace an equal volume of air and this air rushes out at very high velocity. Any surface facing an explosion will be subjected not only to excess hydrostatic pressure but also to pressure from this high velocity wind which travels immediately behind the shock front of the blast wave. This is called the dynamic pressure. Close to the explosion the dynamic pressure may be as great as the hydrostatic pressure of the shock front , but further from the explosion the effect falls off rapidly (M.S. Owen - Smith 1981).

Physical aspects of water - transmitted blast

- Shock wave

When an underwater explosion takes place the gaseous products are subjected to a high pressure. Pressure is transmitted to the water layer in contact with the gases and a shock wave is propagated radially at approximately the speed of sound in water (1450 m/s). The shock wave rises to its maximum in the order of 1 ms. and decays towards zero in the order of a few milliseconds. If the total energy of the explosion, approximately one - quarter is radiated in the shock wave.

(Rawlins J.S.P. 1978)

The blast wave travels much more rapidly and much further in water than in air due to the incompressibility of water.

- Negative phase and mass movement of water are absent or negligible .

(M.S. Owen - Smith 1981)

EFFECTS OF A DEPTH CHARGE

The explosion of a depth charge produces a bubble of gas at a very high pressure of the order of 100,000 atmospheres. This high pressure is transmitted as a pressure pulse. The reflection of this at the free surface of the water produces the characteristic 'dome'. A few seconds later the explosion products, which have formed a bubble many times