# *Surgery of Violence*

## IV. Blast Injuries of the Ear

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The shock front of a blast wave is irregular and can be deflected by obstacles in its pathway, depending on their size and position. Consequently, the injurious effects of blast tend to be capricious, and one person may be unharmed while those around him are killed or severely injured.

In most explosions solid material is changed suddenly into a gas with an enormous increase in volume and thus of pressure. The blast wave spreads outwards from the site of the explosion, initially faster than the speed of sound. The wave consists of a short positive phase followed by a much longer, but less distinct, negative phase. The positive phase may reach very high pressures, and its duration is usually a few milliseconds. The magnitude of the negative phase cannot be greater than atmospheric pressure, but the duration is much longer than that of the positive phase and is usually tens of milliseconds.

### Stimulation Deafness

It is important to differentiate between the different types of airborne stimulation that can affect the ear.

*Noise-induced Deafness.*—In this condition, usually occupational in origin, prolonged exposure to high-intensity noise results in inner ear damage but without any effect on the middle ear.

*Report Trauma.*—This occurs in gunners and is due to repeated stimuli whose duration is less than 1·5 ms. Middle ear damage is rare.

*Blast Trauma.*—This usually results from a single exposure to a stimulus when the duration is greater than 1·5 ms. Middle ear damage is fairly common.

### Ear Damage

Three factors determine the effects of blast on the ear. They are: (1) *The rise time.* The more rapidly the pressure reaches its peak, the greater the likelihood of damage to the ears. (2) *The peak pressure.* Higher pressures result in greater damage. (3) *The duration of the positive phase.* The longer the positive phase, the greater is the damage to the ears.

### Investigation of Ear Damage

Clinical investigation of ear damage resulting from explosions is extremely difficult because of the number of variable factors.

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In considering injuries from different explosions there will be differences in the size of the bombs and in the explosive material used. In any specific explosion there are factors such as the distance of the patient from the bomb, the protection afforded by walls, partitions, or other intervening obstacles, and the direction of the head at the time of the explosion.

The greatest problem arises when assessing the distance of the patient from the bomb. Most people are poor at judging distances under ideal circumstances, but when asked to do so in retrospect, following a harrowing experience, they have considerable difficulty and give wildly inaccurate replies.

Furthermore, in any such investigation problems arise in deciding who should be included. It is usually impossible to trace those who were nearby but uninjured, so that any survey starts off by being selective. To add to the problems one comes across those who, having heard the explosion, perhaps two blocks away, check their hearing and discover a long-standing deafness of which they had been unaware. Man, by his nature, and the Criminal Injuries (Compensation) Act, by its nature, combine to bring out the malingerer and the deaf of long-standing, who may see a silver lining in the cloud that rises from a distant explosion.

It is advisable, therefore, that conclusions should be drawn from a study of a circumscribed group where the distribution of the victims can be established fairly reliably. A particularly tragic explosion fulfilled these criteria and is the subject of a report.[1]

### The "Abercorn" Explosion

In the late afternoon on the first Saturday in March 1972 a small bomb of approximately 5 lb (2·3 kg) exploded in the crowded Abercorn Restaurant. Two girls were killed, four people lost both legs, one of these also losing an arm, and another girl lost one leg. Three people each lost an eye. In addition other people suffered serious injuries to the head, broken bones, burns, and lacerations.

While this was a small bomb, it exploded in a confined space, and most of those in the restaurant were deafened at the time of the explosion. Some could hear nothing at all for many minutes afterwards and described seeing the lips of ambulance men and nurses moving, as in a silent film.

Many of those whose ears were affected by the blast have been under review at the E.N.T. departments of the Royal Victoria and Belfast City Hospitals. Many others were traced and all were asked to indicate on a plan of the restaurant where they had been sitting at the time of the explosion. Over 80 persons who were in or just outside the building were traced and their positions determined. This confirmed the problems of establishing the distance from an explosion when direct inquiry is made from the patient. Most knew clearly where they had been sitting, but their views on the distance from the bomb were very inaccurate.

## Middle Ear Damage

Rupture of the tympanic membrane occurred in approximately half of the persons examined and just under half of these had bilateral perforations. In bilateral cases the perforation in the ear facing the explosion was the larger, while unilateral perforations occurred in the ear nearer the blast in all but one instance. In this exception to the rule the patient was thrown from right to left against the wall, and presumably the reflected blast resulted in the perforation of the left eardrum. Altogether, at least 60 tympanic membranes were perforated.

Animal experiments have shown that the tympanic membranes of the young are stronger and more resistant to blast than those of older animals. Cadaver experiments carried out in 1906[2] showed that pressures averaging 33 lb/in² (2·3 kg/cm²) were required to rupture the drums in children, compared to 20 lb/in² (1·4 kg/cm²) for adults. The findings in this survey appear to confirm this impression, as four children, seated among adults with perforated drums, were unharmed.

## Sensorineural Deafness

Sensorineural (perceptive) deafness was widespread initially, in that almost all patients interviewed were deafened at the time of the explosion. Many recovered rapidly with return to normal hearing within a matter of hours.

In this survey most of the final audiograms were done a year or more after the explosion. Twenty-four patients, almost 30% of those examined, had high-frequency sensorineural loss of hearing averaging greater than 30 dB for 4000 and 8000 Hz in one or both ears. While many of these patients had some tinnitis, the majority were not aware of any significant hearing problem and some were not even aware of any hearing loss. Nine patients, just over 10%, suffered hearing loss which affected not only the high frequencies but also those for speech, but in some only one ear was affected and not all were aware of a handicap.

A hearing loss of at least 40 dB for the speech frequencies in both ears could be regarded as the level at which the loss is serious. Only 6% of all those examined were so affected and probably a smaller percentage of the total in the restaurant, as most of those who were untraced were sitting furthest from the bomb.

In the past it has been suggested that rupture of the tympanic membrane had some protective effect on the inner ear and that the sensorineural loss was greater if the drum remained intact. This does not appear to be so, as every one of those with serious bilateral deafness had ruptured drums.

## Tinnitus

Tinnitus is common and in many cases is the main complaint. It may be severe and cause considerable distress even though the hearing returns almost to normal. It is likely that the emotional stress of exposure to an explosion, with all its associated horrors, aggravates the tinnitus, which in many cases persists indefinitely.

## Vertigo

Some patients complained of dizziness, but most of these suffered a head injury as well. However, a few cases of benign positional vertigo were found without a history of head injury, and in these the blast can reasonably be incriminated.

## Management of Blast Injuries to Ear

### PROPHYLACTIC

The middle ear muscles, stapedius and tensor tympani, play little part, if any, in ear protection in blast situations. The reflex arc producing contraction of these muscles takes 10 ms and by this time the positive phase of most explosions has passed. There is evidence to suggest that when an explosion occurs in a very noisy situation, where the middle ear muscles are already contracted, ear damage is less than would otherwise have been the case.

Cotton-wool in the external auditory meatus affords virtually no protection and is potentially harmful in that it gives a false sense of security. Ear muffs and properly fitted ear plugs are of value in a predictable situation, for example, with gun crews. Bomb explosions tend to be less predictable. When the whereabouts of an unexploded or suspect bomb is known there are two groups of people to be considered: (1) essential personnel, such as police, military, and fire services, who need to be close to the bomb; (2) the general public, who should remove themselves well beyond the range of danger.

The essential personnel must be able to communicate satisfactorily. Ear muffs and ear plugs cause problems in communication, but the "Gundefender" ear plug (Amplivox) maintains almost normal hearing while affording protection.[3] It works on the simple principle that a suitably perforated metal disc will let through normal sounds but will present a barrier to the high intensity blast wave due to increasing frictional resistance. It is desirable, therefore, that personnel likely to be in the vicinity of blasts are fitted with these ear defenders as a prophylactic measure.

### MIDDLE EAR

Of the 60 perforations in the Abercorn explosion, 49 (82%) healed spontaneously without any active intervention. Our approach has been conservative—cleaning out the ears only if foreign material has been driven in by the blast, using systemic antibiotics or ear drops only if there is evidence of active infection, and advising the patient to keep water out of the ears.

One potential problem arises from this conservative approach. Part of the ruptured tympanic membrane may be driven into the middle ear by the blast wave, and spontaneous closure of the drum may leave this enclosed within the middle ear as a potential cholesteatoma. This has been seen in one case so far from the Abercorn explosion, and in a second case an epithelial cyst developed in the middle ear but was visible through the unhealed perforation. Two such cases out of 60 perforations are not seen as sufficient to justify a change of policy but have been enough to advise an open mind on the subject and the maintenance of suspicion when reviewing these cases.

When the perforation fails to show evidence of healing within three to six months, surgical closure is indicated. Usually only a type I tympanoplasty (myringoplasty) is required, but occasionally one or more of the ossicles have been dislocated and the ossicular chain must be reconstructed. The tympanic membrane can be repaired with temporalis fascia, autologous or homologous, or homologous dura mater. Generally the results are good, with over 90% success in closure of the perforation.

### SENSORINEURAL DEAFNESS

It is difficult to control any trials of treatment of sensorineural deafness, as so many untreated patients do so well. Recovery of hearing is usually rapid—during the first few hours. Many patients have improved from very severe deafness to almost normal hearing before it has been possible to do an audiogram. Obviously, therefore, the timing of the first audiogram is important in assessing the effects of any treatment.

A controlled trial following an explosion in a chemical works in Basle suggested that intravenous infusions of low molecular weight dextran facilitated recovery of sensorineural hearing loss.[4] This requires admission to hospital and obviously is not a practical proposition for routine use when large numbers have been exposed to a blast. It is indicated when there is still severe

sensorineural loss a few hours after the explosion and when there are no contraindications related to the other injuries. In less severe cases it is our practice to prescribe vasodilator drugs and steroids, which appear to improve the recovery, though there is no controlled statistical evidence for this.

### Conclusions

Our experience with blast injuries shows that the ear has excellent properties of recovery after exposure to blast, with a high rate of spontaneous repair of the tympanic membrane and improvement of sensorineural deafness. Unfortunately this does not happen in every case, and some patients are left with residual perforations and permanent sensorineural deafness, often accompanied by tinnitus.

All of the E.N.T. surgeons in Belfast have been involved in the management of blast injuries of the ear, and we wish to express our gratitude for the generous and co-operative way in which they have agreed to our reviewing both their notes and their patients.

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# *Clinical Problems*

# Oesophageal Foreign Bodies

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### Summary

**Impaction of foreign bodies in the oesophagus was analysed in 54 patients, 45 of whom were children. Of the 45 children 28 were aged 2-4 years. Coins were the most common foreign body in children (27 cases) while in adults a bolus of meat was most common (nine cases).**

**In 41 children there was no predisposing factor, but an underlying mechanism was detected in 88% of the adults. The mechanisms were of three types: oesophageal (stricture), neuromuscular (myasthenia gravis), and extrinsic and mechanical (ankylosing spondylitis). In children most of the foreign bodies were impacted in the upper oesophagus at the cricopharyngeal junction, which is the narrowest part of the oesophagus, while in adults the foreign body was usually impacted at the site of the predisposing lesion or in the lower oesophagus.**

**In all patients oesophagoscopy was performed under general anaesthesia to remove the impacted foreign body. Complications were more frequent in adults, mainly owing to the underlying condition.**

### Introduction

Oesophageal foreign body impaction and tracheobronchial inhalation are common in children. Inhalation of foreign bodies can result in serious complications including death.[1] Though oesophageal foreign body impaction seems less dangerous inadequate management can also result in serious complications.

We report here on impaction of oesophageal foreign bodies in children and adults and analyse the management and complications of oesophagoscopy performed in both groups for the removal of the foreign body.

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### Patients

Fifty-four patients, 45 children and 9 adults, with impacted oesophageal foreign bodies were analysed. In 32 patients the diagnosis was confirmed by chest *x*-ray examination (anteroposterior and lateral) and in 13 by barium meal examination. Twenty-eight of the children were aged 2-4 years (see table). The type of foreign body varied according to age. The most common foreign bodies in children were coins, being present in 27 cases (fig. 1). In seven children the impacted object was seeds, in one it was meat, and miscellaneous objects were present in the remaining 10. In adults a bolus of meat was impacted in seven cases (fig. 2) and a chicken rib in two.

*Age Distribution of 45 Children and Nine Adults with Oesophageal Foreign Bodies*

| Age (years) | <2 | 2-4 | −8 | −12 | ≤50 | >50 |
|---|---|---|---|---|---|---|
| No. of patients | 7 | 28 | 6 | 4 | 5 | 4 |

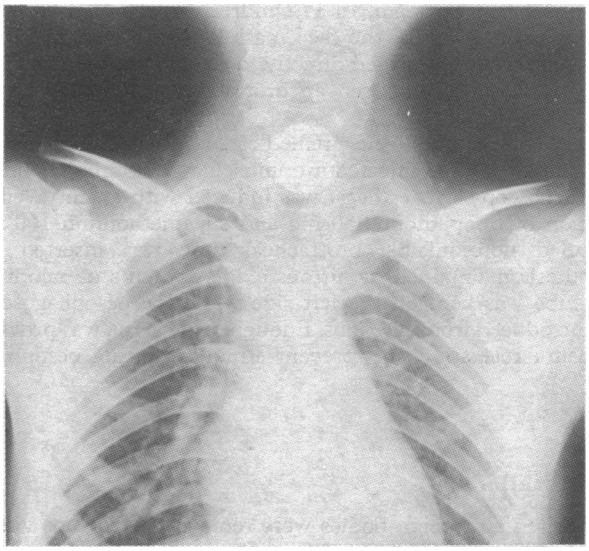

FIG. 1—Anteroposterior chest *x*-ray picture of child showing coin impacted at upper oesophagus opposite 6th cervical vertebra.