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The ENT problems following the Birmingham bombings

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E pur si muove—Yet it moves
(Galileo Galilei)
Revenge proves its own executioner
(John Ford)

ON the evening of 21 November 1974, explosions occurred in two crowded public houses in the centre of Birmingham. Of the victims, 21 were killed (18 outright and 3 died later in hospital). Three medical reports were published which dealt with the surgical problems of the patients involved (Waterworth and Carr, 1975), pulmonary complications (Caseby and Porter, 1977), and the post-mortem findings of the dead victims (Waterworth and Carr, 1976). † This report presents the ENT problems met with in this group of patients.

Patients

Of the patients involved in the blasts, 114 were seen and admitted to Birmingham General Hospital; of these 3 died later. Of the 111 living patients, 41 had ENT complaints (36·93 per cent of living patients), some with more than one complaint:

	Number	% of patients
Deafness	27	25·22%
Tinnitus	26	23·42%
Earache, dizziness, injury to the nose	2 each	1·08% each
Lacerations of ear, voice change, frontal injury	1 each	0·09% each

Of the patients with ENT complaints, 20 had perforated ear drums (18 per cent of living patients); 18 were followed-up. All the perforations were in the *pars tensa,* none in the *pars flaccida.* There was no universal single feature of the perforations; however, it was common for the perforations to have irregular edges with tiny blood clots attached to the

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† Two reports on the nursing management side were published (Whittall, 1975; Bradley, 1975).

TABLE I

Surface areas of perforations	Number
Total	One
Sub-total	One
80%	Three
60%	Three
40%	One
50%	One
30%	Two
20%	Two
10%	Eight
5%	Seven

Total number 29 perforations, twenty-seven followed-up.

N.B. i—Two tympanic membranes had 2 perforations each.
ii—Two perforations, in one of the cases lost for follow-up, were not recorded in sufficient detail to allow a judgement of the surface area.

TABLE II

Sites of perforations:
7 more than 2 quadrants
of the other smaller perforations of 50 per cent or less:
12 central
5 anterior
3 postero-superior

margin. The shape of the perforations was either punched-out or slit-like. Table I shows the surface areas and Table II the sites of the perforations.

Of the 20 patients with perforations:

11 had unilateral perforations—10 healed, 1 persisted

and

9 had bilateral perforations—2 lost to follow-up.

Of the 7 followed-up: In three the perforations healed in both ears. In the other four only one of the two perforations healed (the smaller of the two).

In three of the four patients with bilateral perforations who were left with one perforated ear drum, the blast occurred on the side of the persisting perforation; the fourth patient described the blast as coming from behind.

The large perforations were found on the side facing the explosion, except in one patient who was next to a wall (15 feet from the blast), the ear facing the wall suffering the larger perforation. Patients nearer the blast had the larger perforations. However, two patients were physically away from the blast but, as both were at or near the door of the public house, the blast-wave affected them as if they were just a few feet away from the explosion, with large bilateral perforations, one tympanic membrane in one patient suffering a total perforation.

The total number of perforations was 31, in 29 tympanic membranes (2 tympanic membranes had 2 perforations each; of these four perforations, two involved 5 per cent of the surface area, one 10 per cent and one 20 per cent—all healed). The two cases lost for follow-up had bilateral perforations. Of the 27 perforations followed up, in 25 tympanic membranes, 22 healed (81·48 per cent) with conservative treatment. This figure is very similar to that reported by Kerr and Byrne (1975), when 49 of their 60 perforated ear drums healed (81·6 per cent). In one sub-total perforation, during the process of healing, a band formed across the middle of the perforation, between the umbo and the annulus; this resulted in two persistent perforations. All postero-superior perforations healed with no ill-effects. However, in postero-superior traumatic perforations due to other causes, the ossicular chain is more commonly disrupted (Armstrong, 1972).

A study of the cases in this report shows that rupture of the tympanic membrane does not protect the inner ear. There was no ossicular chain damage in this group of patients.

Discussion

The French military surgeon Ambroise Paré (1510–90) was the first medical writer to mention blast deafness,* Fabricius Hildanus (1560–1634) was the first to report a detailed case, and Archibald Cleland in 1747 was the first to attempt treatment for such deafness (Pahor, 1979a).

The mechanism of blast trauma, and of the blast-waves, has been discussed before (Zuckerman, 1940; Kerr and Byrne, 1975). Blast injuries can be *PRIMARY,* resulting from the effects of variations in environmental pressures; *SECONDARY,* resulting from the subject being struck by flying glass or falling mortar; and *TERTIARY,* resulting from the subject becoming a missile and thus being thrown against solid objects (Hamit, 1973). *QUATERNARY* blast effects form a mixed group which includes asphyxiation by gas, drowning due to burst pipes, . . . etc. (Hadden, 1979). The mechanisms which produce primary injuries to biologic structures include: *spalling,* which results from the interrelation of tension effects produced at an interface between media or tissues of different densities (Fig. 1); *implosion,* which is produced when a pressure wave passes through an incompressible liquid which contains bubbles of gas; *inertia,* which is due to difference in mass; and *pressure differentials,* resulting from the different responsiveness of different media. As the drum is a thin membrane exposed to the external air and fixed to a bony rim, the pressure differentials and inertia cause its rupture. This can account for linear and small perforations. Spalling, which occurs during the positive wave, is the mechanism most likely to produce punched-out perforations,

* It is of interest that the first ever mention of blast deafness was by a literary writer: Michelle de Montaigne (Pahor, 1979a).

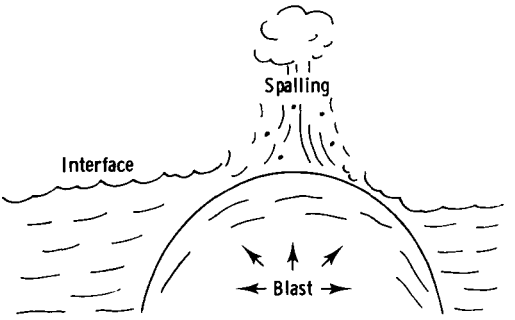

FIG. 1
Diagram to show the mechanism of spalling.

especially the total or near-total loss of the drum head which can be encountered in blast injuries.

In this group of patients, the incidence of deafness was 25·22 per cent. This figure is nearly double that given by Hadden *et al.* (1978), of 67 patients among 1,532, i.e. 12·4 per cent. A possible explanation is that the group studied in the present report were all in a confined place (the two public houses), whereas Hadden *et al's* group of patients must have included a fair number involved in out-of-door explosions.*

In studying cases of blast injuries to the ears in a civilian population it should be appreciated that there are difficulties in following up every case involved; this can also be seen in the example of the Abercorn explosion in Belfast (Kerr and Byrne, 1975).

Deafness

Deafness was noticed immediately after the explosions; this was described dramatically thus:

> 'After the explosion, apart from being in a state of shock, I saw peoples' lips moving as if they were speaking to me, but I heard nothing.'

The general trend was that those nearer to the explosions suffered most, and the ear facing the explosion was worse hit. Exceptions were those which occurred when the patient was sitting next to a wall; then the ear nearer the wall was usually the one most affected, due to the reflected blast-wave. The deafness was much worse immediately after the explosions, but it improved with time. Total deafness can occur, but this steadily recovers within hours.

Soon after the blast the sensorineural deafness, as shown by the

* It is of interest that the first indication of the fact that blast trauma in a confined space is more damaging to the hearing than one in an open space was also mentioned by a literary writer, Charles Dickens (Pahor, 1979b).

audiometric configurations, revealed no one typical curve. The predominant sensorineural hearing loss was a high tone loss, the next most common one being a flat curve with loss in most frequencies. Tetter *et al.* (1970) described four different types of typical audiograms but in this study only their type D (sloping loss) was met. The 'flat hearing loss' was described by Singh and Ahluwalia (1968). The sensorineural deafness took several months to recover, and in some cases up to six months elapsed before the level stabilized. The late audiometric configurations, in cases of sensorineural deafness, were rather similar to those described above, *viz.* high tone or flat curves. The worse the initial deafness, the more likely was the patient to be left with a residual loss.

Three cases with sensorineural deafness had thymoxamine hydrochloride (Opilon) or Lipoflavinoids, but no conclusions could be drawn in view of the small number of cases and the absence of matched controls.

Earache

Earache was a common symptom when asked for, but only two patients made a point of complaining about it; all cases recovered. Earache was invariably accompanied by deafness and tinnitus.

Tinnitus

Tinnitus was as common as deafness and, when both were present in the same patient, they occurred simultaneously. Those who managed to explain it, referred to it as being high-pitched. Tinnitus was usually bilateral and continuous at onset. Later it disappeared altogether, or less often became intermittent before disappearing, usually being worse in the worse affected ear, i.e. the one facing the blast. Eventually tinnitus ceased in all but one case.

Dizziness

Dizziness was complained of by two patients. In one case it was accompanied by various other complaints and it was clear that the question of 'compensationitis' was the underlying cause (Cinnamond, 1974). The second case was that of a patient who suffered from giddy turns before being involved in the explosions, but in whom the dizziness became worse after the explosions and was accompanied by nausea. There was some psychological overlay but there were definite changes in the caloric response, in that it showed a decreased response on the right side. It is of note that the patient had a slit perforation of the left tympanic membrane, which was facing the explosion and involved about 10 per cent of the surface area. However, the giddiness ceased 2 years after exposure to the explosions.

Cord palsy

One case who suffered blast injuries to the lungs, with a bat's wing

radiologic appearance of the lungs (Waterworth and Carr, 1975) also had voice changes. The patient was in the ITU and had PPV for 4 days; large doses of cortisone were administered. The patient also suffered from a ruptured spleen and paralytic ileus. When examined in the ENT department on 19 December 1974 a bilateral cord palsy was found; both cords were in the so-called cadaveric position, the right cord being immobile but the left cord showing some abduction. Two months after the injury, the voice returned to normal and the cords displayed normal mobility. The likely cause of this bilateral cord palsy was a stretching of the nerves due to the blast injury of the lungs.

'Missile' injuries

Severe fatal injuries to the neck resulting from 'missiles' were described by Waterworth and Carr (1976). Apart from minor injuries to the nose and ears, and burns of the auricle and hair around the ear, only one surviving patient had a severe ENT injury from 'missiles', this resulting in a frontal sinus fistula with loss of skin. On exploring the fistula the frontal bone over the fistula was shattered, many bone and wood fragments being removed from the frontal sinus cavity.

Tympanic membrane perforations: Act or wait?

In the present study, 81·4 per cent of the perforations which were followed-up, healed with conservative treatment. Of the 5 perforations which did not heal, one was total, one sub-total and three involved 80 per cent of the surface area, i.e. all 5 involved 80 per cent or more of the surface area of the drum. The other 22 perforations affected less than 80 per cent of the surface area of the drum, and all healed. Thus it is possible to conclude that most perforations involving less than 80 per cent of the surface area of the drumhead would heal, whereas perforations which involved 80 per cent or more can be expected to lead to a permanent perforation. The advice to undertake immediate repair (Ruggles and Votypka, 1973) or early repair (Singh and Ahluwalia, 1968) should be considered in the light of the above findings. It is worthwhile reporting that the healed perforations were all three-layered, as in the rest of the tympanic membrane, whereas in cases of secretory or suppurative otitis media the healed membrane tends to be two-layered.

The time taken by a perforation to heal depends on the size of the perforation; a rough guide, after studying the present series, is to allow one month for every 10 per cent of the surface area lost.

In three cases which underwent myringoplasty the handle of the malleus was on a deeper plane than the long process of the incus,* and in one case it was on the same plane as the incus,—possibly further evidence that blast perforations of the tympanic membrane occur during the

* This observation can also be seen occasionally in tympanic membrane perforations in cases of secretary otitis and chronic suppurative otitis media.

positive phase of the blast. This finding renders placing of the graft underneath the umbo rather difficult, such myringoplasties being better left to more experienced otologists.

There was no difference in the technique or results of drumhead repair in those cases which eventually needed surgical repair and in similar perforations due to other causes. There was no deterioration in the perceptive deafness post-operatively. Post-operatively one case developed granulations on the drumhead which needed surgical removal; this case eventually developed blunting.

In deciding on the question: Tympanic membrane perforation: Act or wait?, one should remember the very high rate of spontaneous healing of the perforations (81·4 per cent); the good quality of spontaneously-healing perforations; the possibility that the concussive effect of blast on the inner ear might render the ear more susceptible to sensorineural deafness in the event of early intervention; the great strain involved in organizing the management of mass casualties (BMJ, 1979; Williams, 1979), when most of the hospitals resources are directed to treating a great number of patients with serious injuries; and last, but definitely not least, the agony which the victims of blast injuries have to pass through, and the anxiety of their relatives and friends:

> 'How blest are those who show mercy;
> mercy shall be shown to them.'

Summary

The ENT problems following the Birmingham bombings of 1974 are presented. It is during the positive phase of bomb blast that the tympanic membrane ruptures. Spalling is a likely explanation for the mechanism of rupture of the tympanic membrane specially in large perforations. Tympanic membrane defects involving 80 per cent of the surface area of the drumhead or more persisted, whereas those involving less than 80 per cent healed with conservative treatment. The majority of perforations (81·4 per cent) healed spontaneously, with a three-layered membrane. A month should be allowed for the healing of every 10 per cent loss of the surface area of the drumhead. During surgical repair of persistent perforations, the malleus handle was found to be on a deeper plain than the long process of the incus. Tympanic membrane perforations did not protect the inner ear, the sensorineural deafness producing either a high tone or a flat loss. One in four of the victims seen in the hospital complained of deafness. A patient who suffered blast injuries to the lung also developed cord palsy.

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