

## Non-Explosive Blast Injury of the Tympanic Membrane in Umuahia, Nigeria

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### Abstract

**Background:** To examine the clinical features and causes of non-explosive blast injury to the ear, as well as the frequency of the State police involvement.

**Method:** Prospective clinical study of consecutive patients with traumatic tympanic membrane perforations resulting from non-explosive blast trauma to the ear without history of previous middle ear disease who attended ENT clinic of Federal Medical Center Umuahia. Clinical features and causes of non-explosive blast injury to ear; healing outcome at 2, 4, 8, and 12 weeks; perforation size versus healing outcome and cause of injury were the main outcomes measured.

**Results:** Five hundred and ninety three new patients with aural disease were analysed. Sixty-one patients, (38 males and 23 females), aged 10-56 years had tympanic membrane perforation from non-explosive blast injury to the ear. The commonest symptoms were hearing loss (64%), tinnitus (61%), and ear ache (57%). The causes of injury were: slap against the ear by State police (31%), spouse (28%), armed bandits (18%), school teachers (8%), parents (5%), and blow against the ear during street fight (10%). Ninety two percent of the perforations healed spontaneously. Healing was associated with significant closure of air bone gap ( $t = 15.08$ ;  $p < 0.01$ ). Non-healing of perforation was significantly associated with the large perforations occupying estimated 50% or more of the entire tympanic membrane area ( $X^2 = 8.67$ ;  $p = 0.003$ ).

**Conclusion:** The ear is very susceptible to injury from non-explosive blast trauma. There was a high spontaneous healing rate of the resulting tympanic membrane perforation, favoring conservative management in most of the case. Non-healing was associated with large-sized perforations. Abusive slap by the State police men was the commonest cause of non-explosive blast injury to the tympanic membrane. Our results are hoped to stimulate a change in the attitude of the culprits and lead to a reduction in the incidence of avoidable TM perforations from slap assaults.

**Keywords:** Blast trauma; non-explosive; tympanic membrane; perforation; spontaneous healing

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### Introduction

Tympanic membrane (TM) serves as a key component of the tympano-ossicular system for sound transmission. Perforation of the TM is common in otologic practice and can result from trauma, infection, and malignant tumours of the middle ear<sup>1-4</sup>. A growing number of papers have been published portraying various aspects of trauma to the TM including other otologic injuries caused by explosive blasts in military and terrorist activities<sup>5-9</sup>. Although few reports deal with non-explosive blast injury which refers to otologic trauma, where a blow to the ear seals the external meatus, and causes a sudden increase of air pressure that strikes the TM<sup>2,3</sup>, this type of ear trauma occurs quite often. In most reports, majority of the causes of the non-explosive blast injuries are regrettably avoidable<sup>2-4</sup>. Our previous publication portrayed various causes of trauma resulting in TM perforation, as well as determinants of spontaneous healing<sup>10</sup>. The present study was initiated after seven consecutive patients with traumatic perforation of TM that were referred to us within a five-week period at the end of the previous study, were all discovered to be caused by slap to the ear by men of the State police. The purpose of the present work is to examine the clinical features and causes of non-explosive blast injury to the ear, as well as the frequency of involvement of the State police men in Nigeria. Our findings are hoped to assist in stimulating a change in the attitude of the culprits, in bringing about a reduction in the incidence of avoidable TM perforations from slap assaults.

### Patients And Methods

**Study design:** This is a prospective longitudinal study conducted during a thirty months period ending September, 2008 in the Ear, Nose, and Throat clinic of the Federal Medical Center Umuahia-Nigeria.

**Ethical Consideration:** The research protocol was reviewed and approved by the Institutional Ethical review Board. Informed consent was obtained from each eligible subject before enrollment into the study.

**Patient Recruitment and Data collection:** Sixty four consecutive patients who suffered a slap or blow to the

ear resulting in acute TM perforations were recruited. Subjects that were included presented within 14 days of the injuries, and had no history of previous middle ear disease. Three patients were excluded on account of previous history of bilateral otorrhoea.

At the initial assessment, a structured interview was conducted for each patient and the following information were recorded: age, gender of patients, side of injury, cause of injury, and associated symptoms. Each patient underwent a thorough ear examination. The location and size of the TM perforations were sketched by hand. The location of TM perforation was determined to be anterior, or posterior or both anterior and posterior with respect to an imaginary vertical line through the manubrium. The size of the perforation was expressed as an estimated percentage of the entire TM area. Standard pure-tone audiometric testing was performed. Pure-tone averages were determined for air and bone conductions at 500, 1000, 2000, and 4000 Hz.

A conservative management approach was adopted by giving 5-day course of cloxacillin prophylactic antibiotics, ensuring the ears were kept dry as well as avoiding any form of interference with the ears by the patients. For those with existing purulent ear discharge, the middle ear infections were treated with appropriate systemic and topical antibiotics and the ears were subsequently kept dry. Follow-up visits were scheduled at 2, 4, 8, and 12 weeks so as to have a uniform baseline assessment at 2 weeks before significant healing would have taken place, and to evaluate the rate of healing at a regular four-weekly interval. During the follow-up visits the eardrums were re-examined. Pure tone audiometric test were repeated following healing of the perforation.

*Analysis of Data:* Data was analyzed with the aid of the Statistical Package for Social Sciences (SPSS), version 11.5. Association between non-healing of TM perforation and group of estimated perforation size was tested with chi square test. Data was presented in simple descriptive form and tables.

## Results

Sixty-one patients with non-explosive blast injury to the ear, representing 10% of 593 new patients with aural disease seen during period under review were enrolled in the study. The group consisted of 38 males (62%) and 23 females (38%). Their age ranged from 10 to 56 years with a mean age of 25.7 years. The right ear was involved in 28 patients (46%) and the left in 33 patients (54%).

All sixty-one patients demonstrated acute perforation of the ear drum that was confined solely to the pars tensa.

Anterior perforations accounted for 25% of the perforations, while posterior perforation occurred in 26% of the patients. Forty-nine percent of the perforations involved both the anterior and posterior halves of the TM. Perforations were small in size in 44 patients (72%), whereas large ones occupying estimated 50% or more of the entire TM area was observed in 17 patients (28%).

The common symptoms in a decreasing order of frequency were: hearing loss (64%), tinnitus (61%), ear ache (57%), purulent ear discharge (21%), and bloody ear discharge (20%).

Ten of 61 patients were lost to follow-up. The TM perforation healed spontaneously in 47 of the remaining 51 patients (92%). Healing of TM perforation was always associated with significant closure of air bone gap. Table I shows the hearing outcomes as at presentation and following healing of the TM perforations. The mean air bone gap at presentation was  $22 \pm 11$  dB, and was  $6 \pm 6$  dB following healing. The difference was significant ( $t = 15.08; p < 0.01$ ).

## Cause of Injury

Aggression by another person was the cause of non-explosive blast injury to the ear in all the patients. It was caused mostly by a slap against the ear in 55 patients (90%) and a blow against the ear by the fist in 6 patients (10%). The latter occurred during street fights.

The culprits responsible for the aggression were portrayed in table II. It was observed that slap directed against the ear by the State police operatives (31%) and spouses (28%) constituted the commonest causes of non-explosive blast injury to the ear. Ninety percent of the patients (victims) that were slapped by the policemen were male drivers working in commercial public transport firms. Their age range was 20-40 years with a mean of 28.5 years. Whereas 88% of the patients that were slapped by their spouse and resulting in TM perforation, were females in the age range of 17-34 years with a mean of 24.8 years. The two male patients that were slapped by their spouses were both unemployed and were aged 51 and 56 years respectively.

The non-explosive blast injury of the ear resulting from the slap against the ears by parents and school teachers accounted for 13% of TM perforations. They were the youngest group of patients aged between 10-15 years. In the six patients that sustained blows against the ear by the fist, their ear injuries occurred during street fights.

**Size of TM perforation versus healing outcome:**

The size of TM perforation was expressed as a percentage estimate of the entire TM which was recorded as 10%, 25%, 50%, and 75%. These were grouped into two: 1) small perforation perforations estimated at less than 50% of the entire TM; 2) large perforation-perforations estimated at 50% or more of the entire TM. Large perforation was significantly associated with non-healing ( $X^2 = 8.67; p = 0.003$ ) (table III). Eighty percent of the perforations that did not achieve healing were large perforations. All the three perforations that were estimated at 75% of the entire TM area did not achieve significant healing. The only small-sized perforation that could not achieve healing had associated history of persistent purulent otorrhea.

**Table I: Hearing Outcomes During the Pre- and Post-healing Phases of Non-explosive Blast Trauma to the Tympanic membrane n = 49**

Air Bone Gap (dB) 0.5, 1, 2, 4 kHz	Mean	SD	Percentage of Patients				
			< 0	0 - 10	11 - 20	21 - 30	> 30
Pre-Healing	22	11	0	18	33	36	13
Post-Healing	6	6	0	84	13	3	0
Percentage Change							
CHANGE (negative values indicate better hearing)	Mean	SD	dB Better		dB Worse		
			d -20	-19 - -10	-9 - 0	1 - 10	>10
Bone conduction (dB) 0.5, 1, 2, 4 kHz	-1.9	11.7	1	3	85	11	0
Air conduction (dB) 0.5, 1, 2, 4 kHz	-16.7	17.8	25	52	19	3	1

**Table II: Aggressors Responsible For Non-Explosive Blast Injury To The Ear n = 64**

Aggressors	Number of Patients	Percentage (%)
State Police	19	31
Spouse	17	28
Parents	3	5
School Teachers	5	8
Street Fighters	6	10
Armed Bandits/Rapists	11	18

**Table III: The Relationship Between Size of Perforation and Healing Outcome. n = 51**

Size of Perforation	Spontaneous Healing of TM Perforation				Total
	4 weeks	8 weeks	12 weeks	Non-healing	
Small perforation	25	8	4	1	38
Large perforation	1	4	4	4	13
Total	26	12	8	5	51

**Discussion**

In wartime or terrorist explosive blast activities, the explosion causes solid and liquid materials to transfer rapidly into gaseous state, with a massive increase in

volume and pressure. The ear is highly vulnerable to the effect of blast. Explosive blast injuries to the ear are rare in peacetime. But a comparable process occurs quite often in non-explosive blast injuries during peacetime, when a sudden blow to the ear seals the external auditory meatus, causing a significant increase of air pressure within the canal. This sudden increase of air pressure within the canal is similar to the short-lived positive phase of blast wave in explosion and can cause rupture of the TM<sup>2,3</sup>. Physical aggression accounted for all the cases in this type of insult to the ear in our series. No case of water sport injury was seen in our study, as reported by other researchers<sup>2,3</sup>. This could be as a result of undeveloped water sports facilities/activities in Nigeria.

It has been reported that TM perforations due to explosion as well as non-explosive blast injury of the ear occur in the anterior portion of TM<sup>11</sup>. In this present study, there was almost equal occurrence of TM perforations in the anterior and in the posterior portion of TM. All perforations were in the *pars tensa*. The distribution of TM perforations observed in our series is similar to those previously reported<sup>2,3,5</sup>. No perforations of the *pars flaccida* have ever been reported.

Spontaneous healing rates of traumatic TM perforation ranging from 79 to 94 percent were reported by various researchers<sup>2,3,12,13</sup>. In view of the excellent spontaneous healing outcome of TM perforation resulting from trauma, conservative management is often generally adopted, and early surgical repair is usually not indicated<sup>2,8,12,13</sup>. Appropriate surgical repair is often indicated for traumatic TM perforation persisting 3-6 months after the injury<sup>13-15</sup>. In this present study, spontaneous healing of the TM perforation with conservative management was observed in 92 percent of the patients. Healing of the perforation was always associated with significant closure of the air-bone gap. This is in agreement with reports from other similar studies<sup>2,3</sup>.

The literature revealed a positive correlation between the size of TM perforation and the spontaneous healing rate<sup>10,12,13,16</sup>. In a particular study, all 22 perforations that involved less than 80 percent of the surface area of the TM healed spontaneously, whereas five perforations that occupied 80% or more failed to heal. Our results similarly portrayed high significant association between size of perforation and non-healing of TM perforation. Eighty percent of the non-healed perforations in our

series were large perforations occupying estimated 50% or more of entire TM area, whereas only one of the 38 small-sized perforations failed to heal. In the latter, it is possible that the complicating middle ear infection was responsible for the non-healing. Our earlier publication showed that ear discharge significantly delays the spontaneous healing rate of TM perforation<sup>10</sup>. All the three perforations that occupied an estimated 75% of the entire TM area failed to heal spontaneously following 12 weeks of conservative management. These data suggest that very large perforations can be expected to lead to permanent perforation, while smaller ones stand an excellent chance of spontaneous healing.

The principal symptoms were hearing loss, tinnitus, and ear ache. This is in agreement with other reports<sup>2,3,5</sup>. All the patients in our series that were slapped by the parents or spouse complained of ear ache. The complaint of ear ache in these circumstances might possibly be influenced by an attempt to attract the attention and sympathy of the aggressor. Similar to the reports in other series<sup>5</sup>, none of our patients complained of vertigo. This is in contrast to some other series that reported complaint of vertigo in small portions of their patients<sup>2,3,16</sup>. It appears the vestibular system is resistant to blast injury.

There are few reports in the literature of the causes of non-explosive blast injury to the ear<sup>2-4</sup>. Analysis of the cause of aggression in one of the reports from a study in Nigeria showed that fight with spouse was the commonest cause of aggression resulting in traumatic perforation of the TM. It further showed that 15.5% of the TM perforations in the series were caused by slap against the ear by the men of state security service<sup>4</sup>. In our present study, men of the police force and spouse were the commonest aggressors responsible for the non-explosive blast injury of the TM (accounting for 31% and 28% of our patients respectively). The lack of proper human rights protection laws and enforcement especially with regard to police

brutality in most developing countries, and the fact that Umuahia (our study location), is one of cities with high concentration of policemen in Nigerian, harboring a regional (Zone 9) and state police command headquarters, were probably responsible for the high incidence of police-related non-explosive blast injury in our series.

It was pertinent to observe that 13 percent of patients that sustained non-explosive blast injury to the ear resulted from child abuse by parents and teachers. This situation was most regrettable as none of the culprits was held accountable, largely because of ignorance and poor enforcement of child rights and protection laws in Nigeria.

The incidence of avoidable non-explosive blast trauma to the ear can be reduced significantly if proper human rights and child protection laws are put in place and adequately enforced. On the part of the physician, every effort should be made to invite the aggressors for adequate counseling. If the aggressor is made to appreciate the resultant injury from his aggressive action to his victim, it may go a long way in restraining him from causing such ear injury in future.

## Conclusion

The ear is very susceptible to injury from non-explosive blast trauma. The effects are similar to explosive blast injury of the ear. The high spontaneous healing rate of the resulting tympanic membrane perforation favored conservative management in most of the case. Healing was associated with significant closure of air bone gap. Non-healing of TM perforation was highly associated with large-sized TM perforation. Abusive, aggressive slap by the state police agents was the commonest cause of non-explosive blast injury to the ear. Our findings are hoped to stimulate a change in the attitude of the culprits and lead to a reduction in the incidence of avoidable TM perforations from slap assaults.

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