

## Acute laryngeal trauma: a comparison between peace time and war injuries

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### Abstract

Thirty-six patients with acute laryngeal trauma are presented. Sixteen patients had peace-time and 20 had war injuries. Peace-time injuries were mostly due to car accidents, violence and suicide using a knife, whereas the war injuries were caused by shell and mine fragments.

Nine patients were treated conservatively (eight peace-time and one war-time) and 27 by surgery (eight peace-time and 19 war-time).

Surgical experience showed that acute laryngeal trauma must be treated within the first 24 hours after injury. Primary treatment must be a definite one. In that way complications and uncontrolled healing can be successfully avoided.

**Key words:** Larynx; Wounds and injuries; War

### Introduction

Despite the superficial position of the larynx and the trachea, the incidence of their injuries by exogenous factors is very small during peace-time as well as in times of war. The location of the larynx between the lower jaw and the sternum, unrecognized injuries in multitraumatized patients, sudden deaths due to asphyxia are some of the many different factors contributing to the low incidence of registered cases of exogenous laryngeal injuries. The majority of peace-time injuries are blunt, due to car accidents, falls, sport injuries or violence, and penetrating injuries are mostly due to stab or gunshot wounds. Some 500 cases have been described in the medical literature (Bent and Porubsky, 1993), confirming that only small numbers of surgeons are familiar with the management of these injuries and that these injuries are a diagnostic and therapeutic challenge (Schaefer, 1990).

Even more rare are reports on the incidence and treatment of war injuries of the larynx. The largest number was documented during the ten-year Lebanon war (Zajtoun *et al.*, 1986). The data on the incidence of such injuries differed greatly, depending on the war event and kind of weapon used even in the same war (Le May, 1971; Jones *et al.*, 1986; Dopson *et al.*, 1989).

A surgeon has an extremely difficult task in reconstructing the laryngeal lumen, restoring the primary function of respiration and hoping that the secondary function, phonation, will resolve as well as possible. Our experience with peace time and

especially with war injuries offers a relatively favourable outlook.

### Patients and methods

In the period from 1975 until 1994, the Department of Otorhinolaryngology and Cervicofacial Surgery of the Dr Josip Benčević General Hospital in Slavonski Brod treated 36 patients with acute laryngeal trauma, 16 with peace-time and 20 with injuries incurred during the war in Croatia 1991/1992 (Đanić *et al.*, 1992; Jelić *et al.*, 1994).

There were 34 male and two female patients, aged five to 68 years (median, 24 years). All peace-time injuries were treated in the first three hours after the injury as were 18 of the war injuries. One war patient with laryngeal contusion was treated on the second day after wounding and one patient with an injury of the larynx inflicted by a plastic explosive was transferred from another medical institution on the fifth day after the injury. Endoscopy, X-ray and CT-scanning were used in pre-operative diagnosis.

Among 36 injured with acute laryngeal trauma, nine (25 per cent) were treated conservatively (eight peace-time and one war-time patient), and 27 (75 per cent) surgically.

All conservatively treated injuries were followed-up for at least 12 months. Among the surgically treated patients, two with war-injury and one with peace-time injury died during the first post-operative week. The cause of death was due to adjacent penetrating injuries of the cervical spine in war injuries and to pulmonary embolism in the peace-

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TABLE I  
AETIOLOGY OF ACUTE LARYNGEAL TRAUMA IN 36 PATIENTS

Peace-time injuries		War-time injuries	
Traffic accident	6	Shells	16
Violence	5	Bullets	2
Suicide	4	Plastic explosive	1
Gunshot wound	1	Contusion	1

time injury. Twenty patients were followed-up at least 12 months post-operatively, and four with war injuries were lost to follow-up.

Of the 36 injured with acute laryngeal trauma 29 (13 war and 16 peace-time) were followed-up and the following points were noted 12 months after injury:

- (1) Respiration:
  - (a) good respiration (patient without tracheostomy, respiration as good as before the injury);
  - (b) bad respiration (patient cannot breath without a tracheostomy).
- (2) Phonation:
  - (a) good phonation (voice as it was before the injury);
  - (b) satisfactory phonation (voice is not as good as it was before the injury but is functional);
  - (c) bad phonation (noticeable hoarseness or aphonia).
- (3) Swallowing:
  - (a) good swallow (no difficulties in swallowing);
  - (b) bad swallow (has difficulties in swallowing).

## Results

Peace time injuries were mostly due to car accidents, violence and suicide using a knife, whereas the war injuries were caused by shell and mine fragments (Table I).

According to the site, there were 19 (52.7 per cent) supraglottic, 12 (33.3 per cent) transglottic and three (8.3 per cent) glottic wounds. Among seven injuries of the cricoid, two were isolated and five were associated with the injury of the thyroid (Table II).

Seven (19.4 per cent) patients (one war injury and six peace-time injuries) had isolated laryngeal injuries and 29 (80.6 per cent) (19 war and 10 peace-time), had adjacent injury of the head and neck, or other parts of the body (Table III).

### Conservative treatment

Conservative treatment was used in nine injured (one war and eight peace-time injuries). They had

TABLE II  
SITE OF ACUTE LARYNGEAL TRAUMA IN 36 PATIENTS

Site of injury	Peace-time	War-time	Total
Transglottic	4	9	13
Supraglottic	11	8	19
Glottic	–	3	3
Cricoid	1	6	7

some oedema, haematomas or lacerations of the endolaryngeal mucosa, mostly in the region of aryepiglottic and ventricular folds. Fractures of the cartilaginous framework of the larynx could not be diagnosed clinically, endoscopically or on CT-scan. A tracheostomy was only performed in one case. All patients received corticosteroid therapy to reduce the oedema and only those with smaller lacerations of the endolaryngeal mucosa received antibiotics. All patients had good respiration, and seven had good and two satisfactory phonation. None had swallowing difficulties (Table IV),

### Surgical treatment

In the war-related injuries, the wounds of skin and muscles, the endolaryngeal mucosa and laryngeal cartilages were treated with 'conservative debridement', i.e., limited removal of the injured mucosa and cartilage. Immediate reconstruction of the laryngeal framework was performed in eight patients with the use of the median layer of the deep cervical fascia (Đanić *et al.*, 1995). Antibiotic prophylaxis was given post-operatively according to the recommendation of the Croatian Ministry of Health Care: penicillin G 4 000 000 I.U. i.v. every six hours + gentamicin 120 mg i.v. every six hours + metronidazole 500 mg i.v. every eight hours (Kalenić *et al.*, 1992).

Depending on the character of the surgical treatment, all patients were divided into four groups (Table V). Tracheostomy was performed in all treated in the groups II to IV.

### Group I

Three patients (two war and one peace time) had soft tissue and skin lesions, and a lesion of the perichondrium without fractures of the cartilages. All had endolaryngeal haematomas or small endolaryngeal mucosa lesions. The wounds were treated surgically without the exploration of the larynx.

### Group II

Nine patients (four war and five peace-time injuries) had larger lesions of endolaryngeal mucosa, especially in the area of the anterior commissure, with smaller linear fractures of the thyroid or cricoid cartilage, without significant dislocation of defect. Lesions of the perichondrium were not significant. They were treated by medial thyrotomy through the existing vertical fracture and conservative debridement of the mucosa, restoring the continuity of the

TABLE III  
ASSOCIATED INJURIES IN 36 PATIENTS WITH LARYNGEAL INJURY

Site of the associated trauma	Peace-time	War-time	Total
Trachea	2	5	7
Pharynx	11	6	17
Oesophagus	0	2	2
Thyroid gland	0	3	3
External jugular vein	6	3	9
Internal jugular vein	0	2	2
Spine	2	5	7

TABLE IV  
TREATMENT RESULTS IN 29 PATIENTS WITH LARYNGEAL INJURY AFTER 12 MONTHS

Type of treatment	N	Respiration		Phonation			Swallowing	
		Good	Bad	Good	Satisfactory	Bad	Good	Bad
Conservative	9	8	0	6	2	0	8	0
Peace-time War		1	0	1	0	0	1	0
Surgical	20	7	0	6	1	0	7	0
Peace-time War-time		13	0	6	4	3	13	0
Total	29	29	0	19	7	3	29	0

mucosa with 4-0 or 5-0 absorbable sutures without tension.

### Group III

Eleven patients (10 war and one peace-time injury) had larger lesions of endolaryngeal mucosa, lesions of the vocal folds and/or ventricular folds, multiple fractures of the thyroid and cricoid cartilage, with defects in the perichondrium and cartilage but with preserved stability of the cricothyroid ring. In five of them, reconstruction of the laryngeal lumen was performed using the median layer of the deep cervical fascia. Besides the lesion of the larynx, one patient also had a partial defect of the first two tracheal rings, so that the cervical fascia was used for the reconstruction of the lumen of both the larynx and the trachea. In addition to the lesion of the cricoid and the first tracheal ring, one patient had a penetrating wound of the oesophagus and cervical spine (C-7). Besides cervical fascia in the reconstruction of the cricoid and trachea, a muscle flap after Miller and Duplechain (1991) was used for the prevention of a tracheo-oesophageal fistula.

### Group IV

Four patients (three war and one peace-time injury) had massive lesions of endolaryngeal structure, comminuted fractures and larger defects of

thyroid and cricoid cartilage, which caused instability of the cricothyroid ring. In one patient, a median layer of the deep cervical fascia was used for the reconstruction of the laryngeal ring, and an endolaryngeal stent was used for the prevention of the ring collapse.

Reconstruction of the larynx was performed with cervical fascia in eight patients. Seven of them had no sign of fascia necrosis, and two developed endolaryngeal granulations which spontaneously resolved. Three patients died during the first week. One patient with a peace-time injury died of pulmonary embolism and two patients with war injuries died because of associated injuries to the cervical spine. Surgically-treated patients were decannulated between the fourth and sixth week. Twenty surgically-treated patients had good respiration without signs of stenosis of the larynx. None had swallowing difficulties.

During 12 months follow-up four patients were lost to follow-up. All patients in the first and second group (one war and five peace-time) of surgically-treated patients had good phonation. In the third group, six patients (five war and one peace-time) had good phonation and four (all with war injuries) had sufficient phonation. Three patients with massive war lesion in the fourth group had bad phonation and one with peace-time injury had satisfactory phonation (Table IV).

TABLE V  
SURGICAL TREATMENT OF 27 LARYNGEAL INJURIES

	Peace-time War-time		Treatment
	No. of patients		
<i>Group I</i> Haematomas, small lesions of laryngeal mucosa and cartilage	1	2	Surgical treatment of the wound without the exploration of the larynx
<i>Group II</i> Large lesions of mucosa, especially at frontal junction, small fractures of the cartilage	5	4	Exploration of the larynx, conservative debridement, primary suture of mucosa
<i>Group III</i> Large mucosal lesions, multiple fractures with defects of cartilage, preserved stability of cartilaginous skeleton	1	10	Exploration of the larynx, MLDCF* reconstruction in seven patients
<i>Group IV</i> Instability of the cartilaginous skeleton	1	3	Exploration of the larynx (MLDCF reconstruction in one patient)

\*MLDCF – median layer of deep cervical fascia used for reconstruction of laryngotracheal war injuries (Đanić *et al.*, 1995).

## Discussion

Wounding with splinters of shells or hand grenades is a common part of every contemporary war; 61 per cent in the WW1, 85 per cent in the WW2, 44 per cent in the Vietnam war, 53 per cent in Israel, 1982, and 56 per cent in the Falklands war (Coup-land, 1991). The majority (80.3 per cent) of our patients had injuries caused by splinters of shells and mines (Đanić *et al.*, 1992), which was typical for the 1991/92 war in Croatia (Matulić *et al.*, 1992). Almost all the wounded were injured within a 100 metre area of the explosion. A blunt splinter enlarges the volume of the wound's temporary cavitation, so that the energy of the splinter at the time of entering the body can be sometimes twenty times greater than that caused by a rifle bullet (Barache *et al.*, 1986). Surgical experience from the 1991/92 war in Croatia also showed that non-streamlined projectiles of shell cause multiple wounds, penetrate deep enough to cause internal lesions, act thermally and produce a larger permanent cavity (Lovrić *et al.*, 1994).

Penetrating injuries of the neck can tear the laryngeal skeleton and, additionally, cause damage to a variety of vessels and nerves that pass through the cervical region. Ninety-five per cent of war injuries of the larynx were associated with neck and body injuries. This figure in our series reduced to 63 per cent in peace-time injuries.

There is no unique algorithm for the treatment of penetrating neck war injuries. We followed two approaches in the exploration of vital neck structures: selective exploration in peace time, and obligatory exploration in war time injuries.

According to Haugh and Giles (1992), one laryngeal fracture to every 650 peace time fractures of the facial bone (0.15 per cent) can be expected. In our case that number was significantly higher: 0.94 per cent in peace time and 3.70 per cent in war injuries.

No unique surgical method could be recommended in the treatment of the injured larynx. Defects of the thyroid cartilage, with denuded surfaces which favour infections and diminish functional results, inspire many authors to use different materials for their covering and reconstruction. The use of skin grafting for exposed cartilage or placement of a skin graft over laryngeal stents (Olson and Miles, 1971; Olson, 1978) proved unsatisfactory due to rejection or necrosis. Better results were obtained with mucosa of the piriform sinus, with removed arytenoid and mobilized mucosa in the shape of a flap with a wide basis (Dedo and Sooy, 1968). Use of an undamaged epiglottis is more complicated, but larger defects can be better covered by this material than with piriform sinus mucosa; however, this mucosa is often damaged and not usable for larger injuries (Pennington, 1964). In the reconstruction of the larynx after gunshot blast, Cassisi (1990) recommended a composite graft of the septal cartilage and definitive repair seven to ten days after wounding. Our experience with war injuries of the larynx supports Schaefer's recommendation (1991) that significant laceration of laryngeal

mucosa can be primarily repaired if performed within 24 hours of injury, with minor mobilization of the adjacent mucous membrane and 'conservative debridement' of war injuries, without using skin grafting.

Formation of a new laryngotracheal ring with the use of sternohyoid muscle has been described by several authors (Calcaterra, 1983; Schaefer, 1990; Eliachar and Tucker, 1991). We used the median layer of the deep cervical fascia for reconstruction, with excellent results. There was no need in our series for total laryngectomy after penetrating bullet injury as described by Harrison (1984). There is no singular surgical technique to reconstitute the injured larynx. The surgeon must have at his disposal many techniques and the ability to select a particular technique for each individual case.

Good functional results in treating peace-time exogenous injuries of the larynx are due to minor endolaryngeal lesions which in more than half of the patients only required conservative treatment. The majority of the surgically-treated patients were among the first two groups (with mostly supraglottic localization of the injury) resulting in good phonation and respiration after treatment.

The majority of the war injuries of the larynx were transglottic or glottic, mostly in groups III and IV of the surgically treated patients. Therefore, the functional results were slightly poorer, partly because of adjacent injuries of other vital structures of the neck which slowed the healing of the laryngeal lesions.

## Conclusion

Surgical experience gained from the 1991/92 war in Croatia with the war injuries of the larynx and 20 years of experience with peace-time injuries, has shown us that these patients must be treated within the first 24 hours after injury. In that way complications and uncontrolled healing of the laryngeal injuries can be successfully avoided. Primary treatment must be a definite one; in cases with larger defects we recommend the use of cervical fascia repair. In peace-time injuries, exploration of the neck can be selectively applied but it must be obligatory in the case of war injuries.

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