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Case Series

The Role of Computed Tomography in Laryngotracheal Trauma: A Case Series

دور التصوير المقطعي المحوسب في الإصابات الحنجرية الرغامية : مجموعة من الحالات

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Abstract

Laryngotracheal injuries are uncommon but often life threatening. Forensically, the assessment of survived cases is usually based on the external findings and several subjective elements such as reports from the involved persons and witnesses. Therefore, the need for more objective methods is crucial for forensic experts. Clinical computed tomography (CT) is sufficiently advanced to provide detailed descriptions of the internal structures. This study aims to evaluate the use of CT in survived and non-survived cases of laryngotracheal trauma.

A total of five patients were included in this study (4 survived cases and one deceased). Information and data were collected retrospectively from medical records; radiological images were analyzed. The study involved three cases with injuries which resulted from blunt trauma caused by an alleged boating accident and sporting accidents, as well as two cases with injuries as a result of medical malpractice.

During history taking, type of injury may help in early diagnosis and fast provision of treatment to patients. Blunt types of injury may require the help of CT more than acute injuries for early diagnosis and treatment.

Keywords: *Forensic Sciences, Laryngotracheal Trauma, Computed Tomography, Blunt trauma, Anatomy*

المستخلص

تعتبر الإصابات الحنجرية الرغامية غير شائعة ولكنها غالباً ما تهدد الحياة. على الصعيد الجنائي، يستند تقييم الحالات التي يكتب لها النجاة على المشاهدات الخارجية وعدة عناصر شخصية مثل تقارير الأشخاص المعنيين وشهادات الشهود.

ولذلك، فإن الحاجة لمزيد من الأساليب الموضوعية لتقييم أدق لهذه الإصابات أمر حاسم للخبراء الجنائيين. ويعد التصوير المقطعي المحوسب (CT) في الحالات السريرية أداة متقدمة بشكل كافٍ لتوفيرها وصف تفصيلي للإصابات والبنية الداخلية.

وتهدف هذه الدراسة إلى تقييم استخدام الأشعة المقطعية في الحالات الناجية وغير الناجية للإصابات الحنجرية الرغامية. وتضمنت الدراسة ما مجموعه خمسة مرضى (4 حالات ناجية وحالة متوفاة). وجمعت المعلومات والبيانات بأثر رجعي من السجلات الطبية؛ وتم تحليل صور الأشعة المحفوظة. وشملت الدراسة ثلاث حالات مصابة ناتجة عن إصابة كليلة بسبب حادث زورق مزعوم والحوادث الرياضية، فضلاً عن حالتين مع إصابات ناتجة عن سوء الممارسة الطبية.

وخلال أخذ التاريخ المرضي، فإن نوع الإصابة قد يساعد في التشخيص المبكر وسرعة تقديم العلاج للمريض. قد تتطلب الإصابة الكليلة مساعدة بواسطة التصوير الطبقي المجوسب أكثر بالمقارنة مع الإصابات الحادة من أجل التشخيص المبكر والعلاج.

الكلمات المفتاحية: علوم الأدلة الجنائية، الإصابات الحنجرية الرغامية، التصوير المقطعي المحوسب، الإصابات الكليلة، التشريح

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1. Introduction

The neck region is an important part of the body, as it contains vital structures necessary for normal functioning. Damaging these structures can be life-threatening and may lead to significant long-term morbidity or mortality of individuals. Laryngohyoid and laryngotracheal complexes are vital structures, which are essential for the functions of breathing, swallowing and voice production. Any injury to these structures could affect one or all of these necessary functions. Clinically, there are several methods to assess laryngotracheal trauma. These include physical examination, imaging such as Computed Tomography (CT), MRI, laryngoscopy, as well as surgical exploration in severe and unclear cases. Forensically, the assessment of survived cases to evaluate the life-threatening nature of the trauma is usually based on external findings (e.g. petechial hemorrhages and marks on the skin) and several subjective factors (such as statements of the involved persons and witnesses). This study was undertaken to evaluate the use of clinical CT in laryngotracheal injuries in several aspects especially their patterns and causes.

2. Materials and Methods

A total of five patients were included in this study (four survived cases and one deceased) (Table-1). The inclusion criteria were trauma of tracheal and/or laryngeal skeleton injuries treated from 2006 to 2009 at the ENT clinic, Fremantle Hospital, Western Australia. Information and data were collected retrospectively from medical records and radiological reports. Consent was taken from all patients to use their data for research and publication. Radiological images were analysed. The five patients included three females and two males, with an average age of 44 years, ranging from 19 to 71 years.

3. Results

Case One: Axial helical multislice CT imaging was performed through the neck with intravenous contrast (Figure-1). It shows a comminuted fracture through the left side of the posterior aspect of the cricoid cartilage with intra- and extralaryngeal haematoma. The left side of the cricoid was displaced slightly antero-superiorly, which resulted in some distortion in the position of the arytenoids to the left. The left vocal cord was displaced medially as a result of a soft tissue mass extending superiorly from the level of the cricoids fracture to a supraglottic position. It caused narrowing of the airway at the level of the glottis and infraglottic larynx. The airway remained patent. No subcutaneous emphysema was seen in the extralaryngeal location without evidence of a cervical spine fracture. Nasolaryngoscopy showed left vocal cord haematoma, left arytenoids and aryepiglottic fold haematoma.

Case Two: CT with intravenous contrast was performed. A mildly displaced lateral fracture of the right thyroid ala was noted inferior to the laryngeal prominence along with an undisplaced fracture of the left thyroid ala (Figure-2). The anterior fragment tilted laterally, and a small volume of gas was present superior to the fracture. Soft tissue edema/haematoma was noted deep to the left thyroid ala, and this distorted the supraglottic airway, resulting in a mild reduction in airway diameter. The swelling extended superiorly, affected the left vallecula, and extended inferiorly to the level of the most superior extent of the cricoid cartilage. Clinical examination revealed soft tissue injury to the vocal cords. Alignment of the cervical spine was normal and the major neck vessels opacified normally.

Case Three: The CT scan showed extensive air leak a with large volume of subcutaneous emphysema, pneumomediastinum, pneumopericardium and right pneumotho-

Table 1- *Description of cases included in this study.*

	Case 1	Case 2	Case 3	Case 4	Case 5
Age (Years)	38	32	61	19	71
Sex	Female	Male	Female	Female	Male
Cause of trauma	Sporting accident	Sporting accident	Medical malpractice	Boating accident	Medical malpractice
Mechanism of injury	Blunt	Blunt	Penetrating	Blunt	Penetrating
Diagnostic Method	Laryngoscopy, CT	Laryngoscopy, CT	Laryngoscopy, surgical exploration, CT	Laryngoscopy, surgical exploration, CT	Laryngoscopy, CT
Clinical findings	Pain, Bruising, Redness, Tenderness, Hoarseness, Dysphagia, Dysphonia, Hemoptysis	Pain, Tenderness, Hoarseness, Dysphagia, Dysphonia	Pain, Deviation of larynx, Redness, Swelling	Bruising, Pain, Redness, Tenderness, Deviation of larynx, Hoarseness, Dysphagia, Dyspnea, Dysphonia	Hoarseness
CT findings	Extra-laryngeal haematoma, Intra-laryngeal haematoma, Cricoid fracture, Dislocation of left arytenoid	Subcutaneous, emphysema, Extralaryngeal, Haematoma, Intralaryngeal,Haematoma,Thyroid fracture	Subcutaneous, emphysema, Extra-laryngeal, haematoma, Intra-laryngeal, haematoma, Pneumomediastinum pneumopericardium pneumothorax	Subcutaneous emphysema, Extra-laryngeal haematoma, Intra-laryngeal haematoma, Thyroid fracture, Dislocation of epiglottis, Mandibular fracture, Maxillary fracture, Multiple dental injuries, Foramen transversarium bilateral fracture (C6)	Dislocation of the left arytenoid

rax (Figure-3). The tracheaostomy tube was *in situ* with its tracheal entry being at the level of the seventh cervical vertebra (C7) and its lower tip being at the level of the second thoracic vertebra (T2). The tracheostomy tube balloon inflated to a diameter of 35mm, which was approximately twice the diameter of the normal trachea. It was conceivable that a portion of the tracheostomy tube balloon was extra-tracheal. The trachea immediately above the tracheostomy balloon had leftward deviation. The trachea below the tracheostomy balloon was patent. Neither intravenous gas nor drainable liquid collection was observed in the neck.

Case Four: CT scan showed extensive surgical emphysema (Figure-4) and marked haematoma/fluid surrounding the endotracheal tube at the level of the hypopharynx. Swelling of the larynx and pre-vertebral soft tissue was demonstrated. There were comminuted fractures of the right body of the mandible and mental mandible, intra-articular fracture of the right mandibular head, multiple

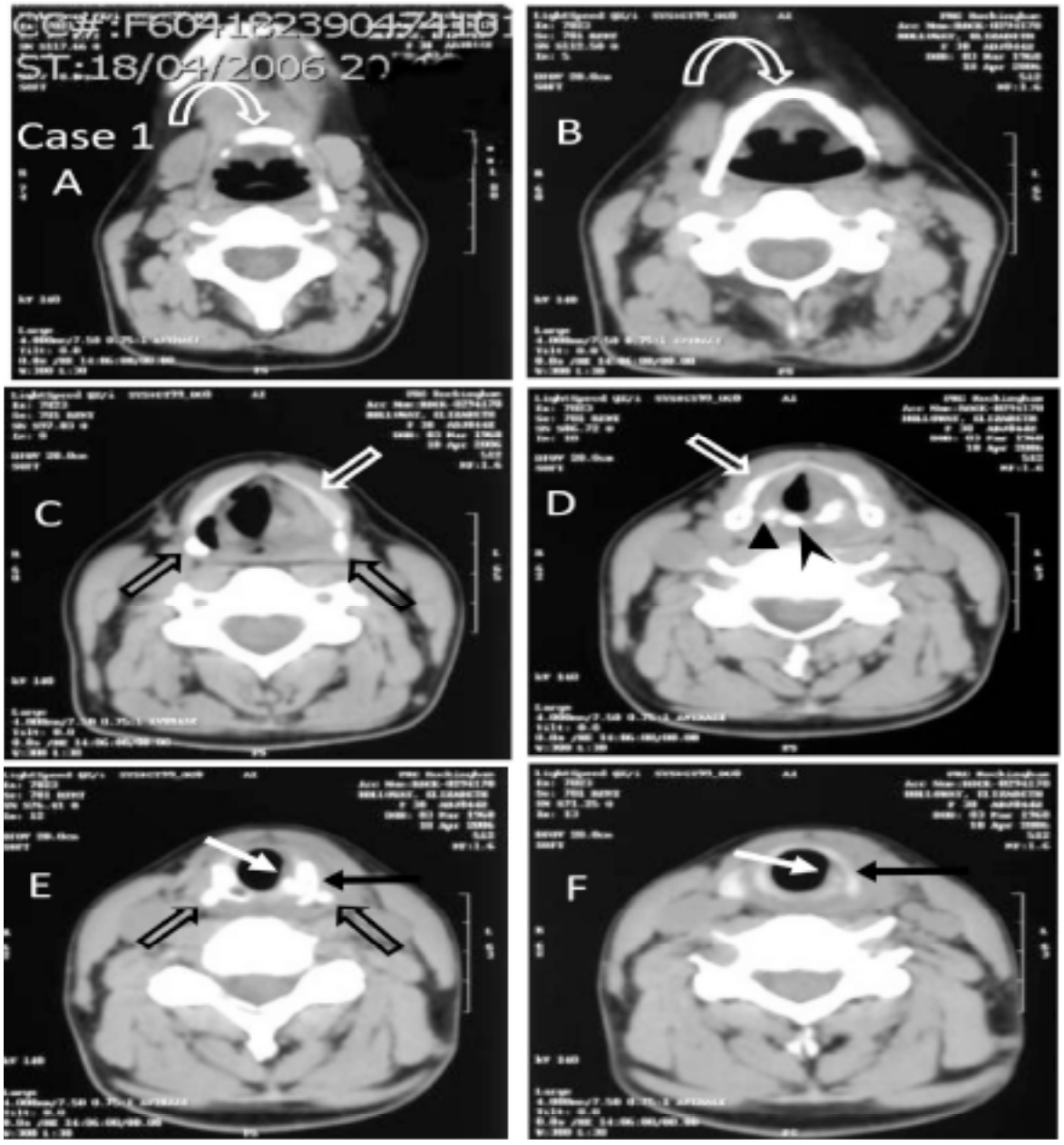

Figure 1- *CT images showing comminuted fracture through the left side of the posterior aspect of the cricoids with anterior displacement (E, F: black arrow) which results in narrowing of the airway (E, F: white arrow). Hyoid bone appears normal (A, B: white curved arrow). Superior horn (C: black-block arrow); inferior horn (E: black-block arrow); thyroid lamina (C, D: white-block arrow); cricoid cartilage (E, F: black arrow); corniculate cartilage (D: black-arrow head); arytenoid cartilage (D: triangle) show almost complete opacity*

dental injuries, and fractures of the anterior maxilla involving the upper and lower incisors. The hyoid bone appeared intact. Bilateral fractures of the foramen transversarium of the sixth cervical vertebra (C6) with minimal displacement was evident (Figure-4). No evidence of carotid or vertebral artery dissection was seen. CT scan of thorax showed pneumothorax, extensive subcutaneous emphysema and pneumomediastinum.

Case Five: CT scan of the neck showed that the left arytenoid displaced anteriorly and medially from the left posterolateral facet of the cricoids (Figure-5). This bowed the

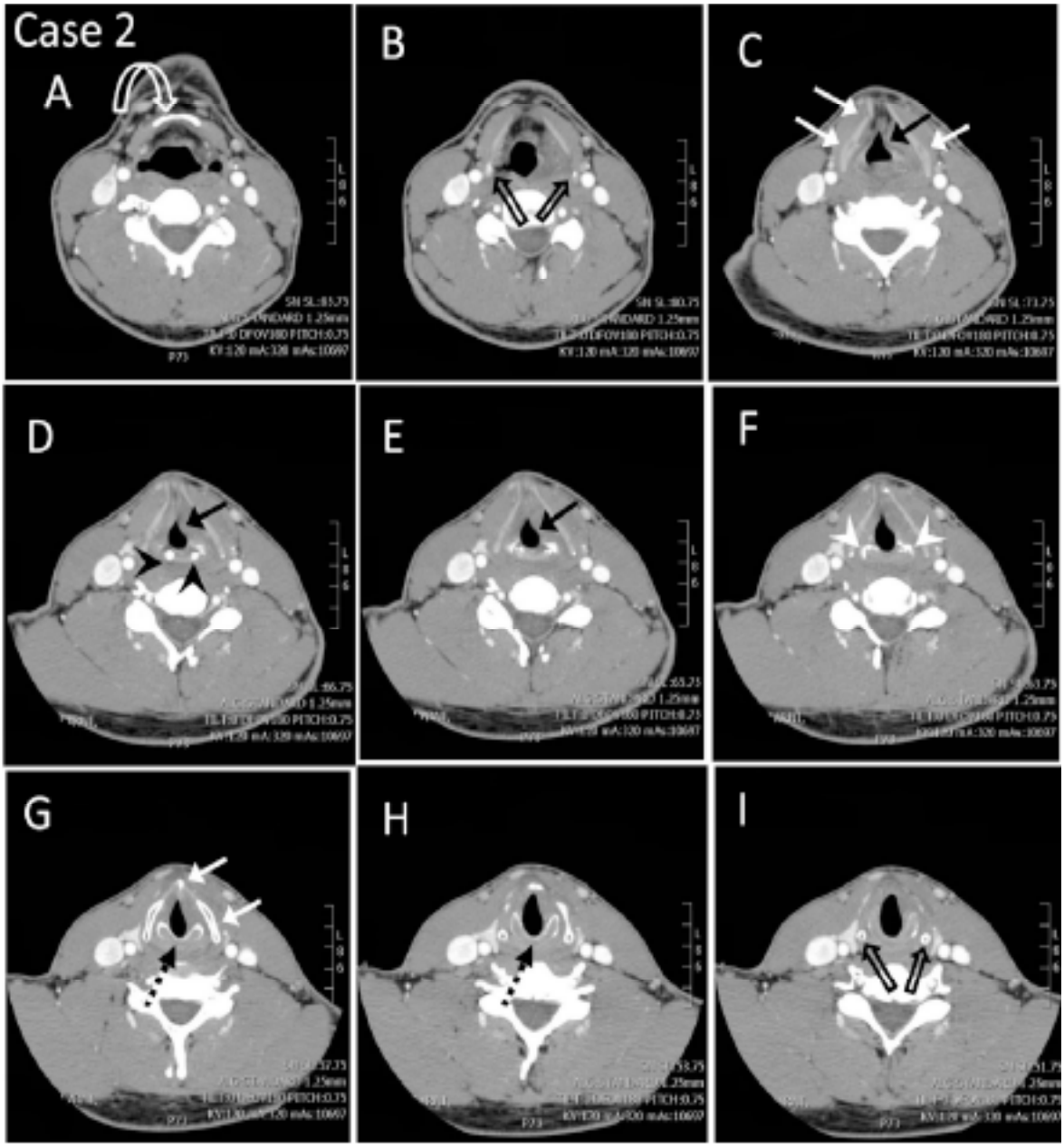

Figure 2- *Series of CT images showing two sites of displaced fractures of right thyroid ala and undisplaced fracture of the left thyroid ala (C: white arrow). Also, haematoma can be seen deep to the left thyroid ala (D, D, E: black arrow). Hyoid bone appears normal (A: curved arrow). Superior horn (B: black-block arrow); inferior horn (I: black-block arrow); corniculate cartilage (D: black arrow head) and arytenoid cartilage (F: white-arrow head) show complete opacity. The thyroid lamina (C, G: white arrow) and cricoid cartilage (G, H black-dot arrow) show partial opacity.*

posterior left vocal fold medially. No soft tissue mass oedema was seen. The right arytenoid was positioned normally on the cricoid.

4. Discussion

The cartilages and muscles of the larynx develop from mesenchyme (derived from neural crest cells) of the fourth and sixth pairs of pharyngeal arches [1]. At approximately the 10th week of gestation, the laryngeal epithelium proliferates rapidly, resulting in a temporary occlusion of the laryngeal lumen. A pair of lateral recesses (the laryngeal ventricles) are produced from vacuolization and recanali-

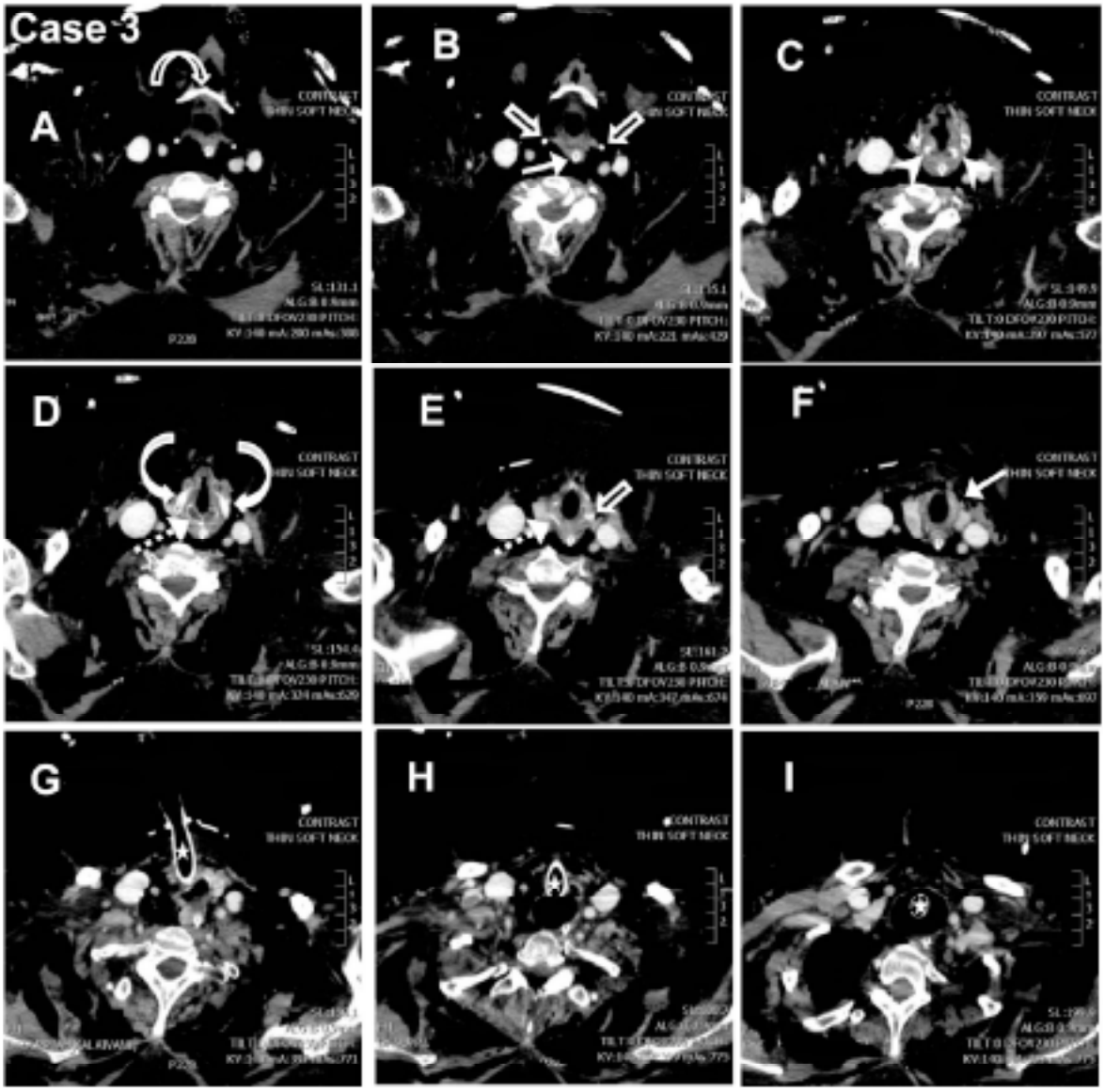

Figure 3- *Severe bilateral subcutaneous emphysema can be seen at the level of the hyoid bone, laryngeal cartilages and the trachea (A-I) which caused leftward deviation of the larynx, trachea and also the esophagus (B: white-solid arrow). Image (F) shows the beginning of the tracheal rings (white-solid arrow). The tracheostomy tube can be seen in situ (G, H, I: star). Hyoid bone is normal (A: curved-block arrow). Complete opacity is shown by superior horn (B: white-block arrow); inferior horn (E: white-block arrow); arytenoid cartilage (C: arrowhead). However, partial opacity is seen in the thyroid lamina (D: curved-solid arrow) and cricoid cartilage (D, E: white-dot arrow).*

zation of the larynx. Both recesses are bounded by folds of mucous membrane that become the false and true vocal cords. The epiglottis originates from the caudal part of the hypobranchial eminence which is produced by proliferation of mesenchyme in the ventral ends of the third and fourth pharyngeal arches [2].

The neck is a very vulnerable area, enabling access to vital structures such as the trachea, larynx, and large vessels. In adult males, the larynx lies opposite to the 3rd-6th cervical vertebrae while it tends to be higher in adult females [3].

Karogha et al. reported two cases of acute injuries of larynx and found that CT scanning was useful among patients with a stable airway if the image findings influence the subsequent treatment of the patient. Their findings correspond to our case one and two with comminuted frac-

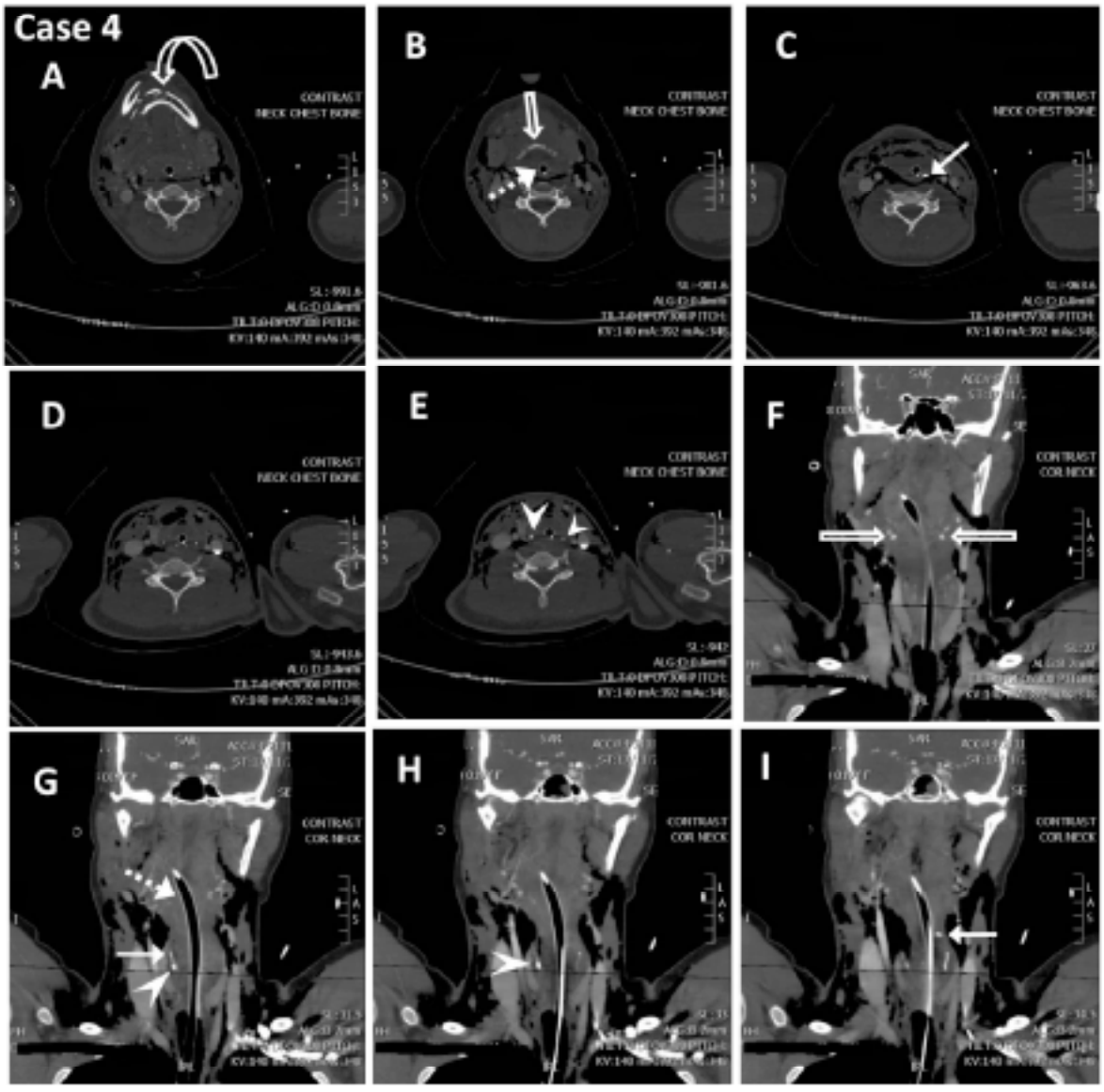

Figure 4- *Transverse and coronal CT images showing extensive surgical emphysema, pre-vertebral soft tissue swelling and marked haematoma surrounding the endotracheal tube. There is an increase in the physiological space between hyoid bone (B, F: white-block arrow) and the larynx (C, G, I: white-solid arrow). Endotracheal tube can be seen in situ (B, G: white-dot arrow). Comminuted fractures of the right body of the mandible (A: curved-block arrow). Hyoid bone appears normal (B, F: white-block arrow). Left Superior horn (C, I: white-solid arrow) and inferior horns (E, G, H: arrowhead) show complete opacity. Thyroid ala shows partial opacity (G: white solid arrow).*

tures of cricoid and thyroid cartilage [4].

Francis et al. found 12 laryngeals, 8 tracheal, and 3 combined injuries. Nineteen patients had penetrating trauma and four had blunt injury. Flexible laryngoscopy diagnosed the injury in 75% of the cases, whereas CT scan diagnosed the injury in all the cases. In our study, three cases occurred from blunt trauma and the fourth involved penetrating trauma [5].

Schafer reported that in the patient with a stable airway, CT scanning of the larynx is useful, if the imaging findings influence the subsequent treatment of the patient [6].

CT imaging was shown to be beneficial in: a)patients with a significant history of blunt force trauma to the anterior neck with or without significant abnormal findings on physical examination, particularly with dysphonia or hemoptysis, b) patients in which the condition and conti-

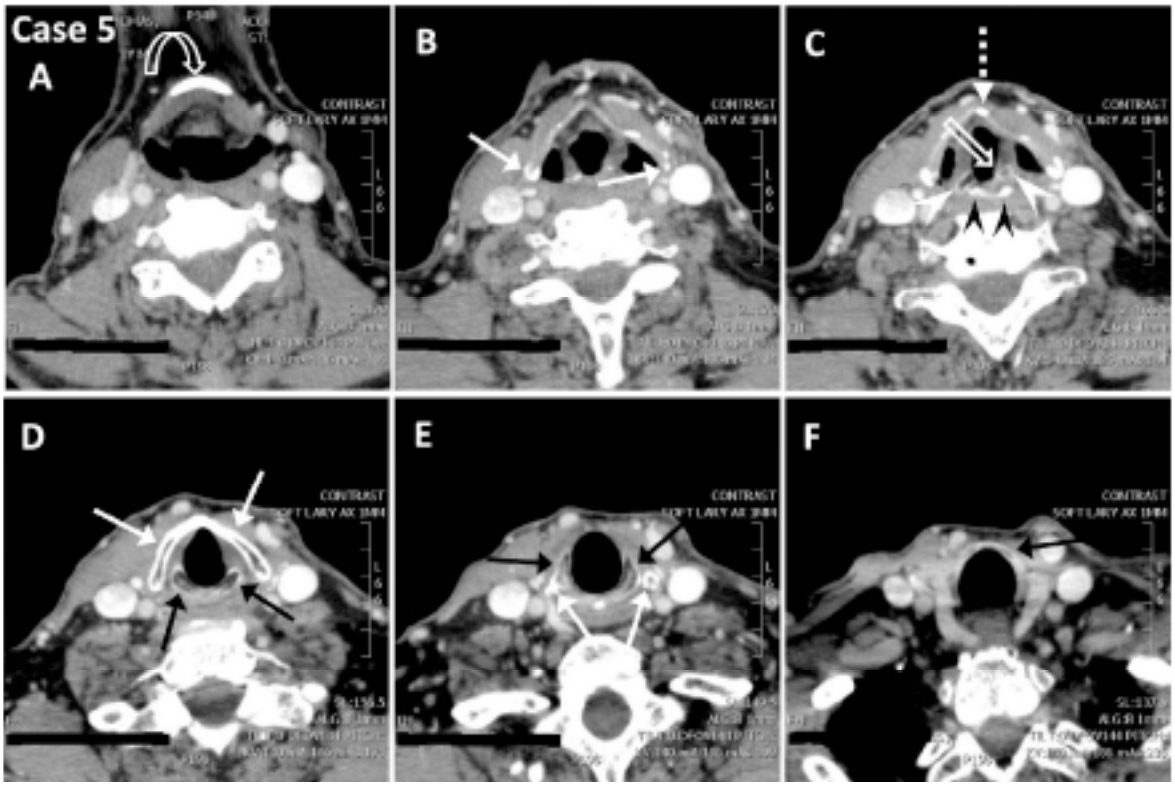

Figure 5- *CT images showing anteromedial displacement of the left arytenoid cartilage (C: white block arrow). Hyoid bone appears normal (A: white-curved arrow). Complete ossification can be seen in the following structures: superior horn (B: white-solid arrow), inferior horn (E: white-solid arrow), midline of thyroid lamina (C: white-dot arrow), thyroid lamina (D: white-solid arrow), arytenoid cartilage (C: white-arrow head), corniculate cartilage (C: black-arrow head), and the cricoid cartilage (D, E, F: black-solid arrow).*

nuity of the endolarynx and trachea is not observable due to edema or hematoma, c) patients in which the extent of injury is uncertain, and d) cases where imaging can be performed under the supervision of a physician proficient in establishing an emergency airway [7].

The diagnosis of acute laryngeal injury is shown to be difficult and may be missed even by experienced radiologists. If acute laryngealinjury is suspected, 2D and 3D CT reconstructions may provide additional diagnostic utility to multiaxial CT imaging [8].

There is usually no significant delay in obtaining a CT during the management of stable patients. A thin-slice axial CT may be useful not only for demonstrating the extent of cartilage and soft-tissue injuries, but for defining the anatomic limits of the injury and the degree of airway obstruction as well. Axial CT also allows the physician to assess any concomitant injuries involving adjacent structures in the neck, skull, spine, and chest. A sagittal projection may further enhance the three-dimensional perception of the trauma, a spiral (helical) CT with virtual bronchoscopy capability may provide additional valuable information [9].

Incisions, stabs, blows and manual pressure to the neck area can prove very dangerous. CT scan has been one of the most effective diagnostic tools for lesions in the upper airways [10]. By using CT, damage to the internal structures of the neck can be visualized in order to present findings that are more objective. Therefore, in order to interpret CT findings correctly, forensic experts should understand the normal CT appearance of laryngotracheal anatomy. Recently, the CT imaging technique was introduced as an investigation tool in the field of forensic medicine and pathology to evaluate both survived and deceased cases [11-

18].

Although laryngotracheal separation has been discussed in several studies and is considered life-threatening [19-23], meticulous review of the literature did not reveal any report about laryngopharyngeal separation injury. To our knowledge, the present study is the first to report this very uncommon type of injury, which involves the complete separation of larynx and pharynx (case-4).

The observation of the CT images in case-5 showed an anteromedially displacement of the arytenoid cartilage. This type of injury is usually associated with injuries which result from iatrogenic causes. According to the CT image, the direction of the dislocation correlates with what has been described in the literature [24-26].

In the current study, a patient died at the age of 61 (case-3). During the admission of the patient to hospital, a percutaneous tracheostomy was inserted which was complicated by tracheal perforation. The CT scan shows extensive air leakage, with a large volume of subcutaneous emphysema, pneumomediastinum, pneumopericardium and right pneumothorax. However, these CT findings do not necessarily mean that the trachea is ruptured. Fibroscopic endoscopy revealed a rupture of the posterior part of the second to the fifth tracheal cartilage rings, which was confirmed by the surgical exploration. The trachea consists of imperfect rings, being deficient in the posterior wall where the rings are completed by fibrous tissues. The ossification of the tracheal cartilage rings has been reported to take place after the seventh decade [27]. This could explain the failure of the CT scan to demonstrate definite signs of a tracheal ring rupture as the patient was still in her sixth decade.

Minor endolaryngeal lacerations and abrasions may be observed, whereas more significant injuries require primary closure via a thyrotomy. Laryngeal skeletal fractures should be reduced and fixated. Endolaryngeal stenting is reversed for massive mucosal trauma, comminuted fractures, and traumatic anterior commissure disruption [7].

CT and fiberoptic endoscopic investigation performed after obtaining a quick history of mechanism of injury may prove vital in assessing mode of treatment in acute and blunt laryngotracheal trauma cases.

5. Conclusion

CT images assist a clinician and forensic expert to evaluate external and internal injuries for the interpretation of life threatening nature of the trauma. Clinical CT images may contribute important information to indicate the site of the internal injuries. This study indicated the benefits of CT imaging in assessment of cases of laryngotracheal trauma.

CT images are useful in court to present more objective evidence. Therefore, it is likely that in the future, courts will rely on image findings of survived and non-survived cases as acceptable evidences. CT, especially multi axial CT, may prove to be a powerful assessing tool, especially when combined with surgical exploration.

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Conflict of interest

The authors have no conflicts of interest to disclose.

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