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Iatrogenic injuries to the trachea and main bronchi

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Abstract

Introduction: Iatrogenic tracheobronchial injuries are rare.
Aim: To analyse the mechanism of injury, symptoms and treatment of these patients.
Material and methods: Retrospective analysis of hospital records of all patients treated for main airway injuries between 1990 and 2012 was performed.
Results: There were 24 patients, including 21 women and 3 men. Mean time between injury and initiation of treatment was 12 hours (range: 2-48). In 16 patients the injury occurred during tracheal intubation, in 1 during rigid bronchoscopy, in 1 during rigid oesophagoscopy, in 1 during mediastinoscopy and in 5 during open surgery. Mean length of airway tear was 3.8 cm (range: 1.5-8). In 1 patient there was an injury to the cervical trachea and in the remaining 23 in the thoracic part of the airway. The treatment included repair of the membranous part of the trachea performed via right thoracotomy in 10 patients (in 1 patient additionally coverage with a pedicled intercostal muscle flap was used), a self-expanding metallic stent in 1 patient, suture of the right main bronchus and the oesophagus in 1, left upper sleeve lobectomy in 1, right upper lobectomy in 1, implantation of a silicone Y stent in 3, mini-tracheostomy in 1, and conservative treatment in 5 patients.
Conclusions: Intubation is the most frequent cause of iatrogenic main airway injuries. Patients with these life-threatening complications require an individualised approach and treatment in a reference centre.
Key words: trachea, airway, iatrogenic injury.

Streszczenie

Wprowadzenie: Urazy jatrogenne tchawicy i głównych oskrzeli zdarzają się rzadko.
Cel: Analiza mechanizmu urazu, objawów i leczenia pacjentów.
Materiał i metody: Retrospektywna analiza dokumentacji szpitalnej pacjentów leczonych z powodu urazów dróg oddechowych obejmowała okres między 1990 a 2012 r.
Wyniki: W badaniu wzięło udział 24 pacjentów, w tym 21 kobiet i 3 mężczyzn. Średni czas trwania uszkodzenia wynosił 12 godzin (zakres: 2–48). Uraz wystąpił u 16 pacjentów podczas intubacji, u 1 – podczas sztywnej bronchoskopii, u 1 – podczas sztywnej ezofagoskopii, u 1 – podczas mediastinoskopii i u 5 – podczas zabiegów chirurgicznych. Średnia długość rozdarcia to 3,8 cm (zakres: 1,5–8). U 1 pacjenta stwierdzono uraz tchawicy w szyjnym odcinku, a u pozostałych 23 – w części piersiowej. Zabieg chirurgiczny obejmował naprawę błoniastej części tchawicy z dostępu poprzez prawą torakotomię u 10 chorych (u 1 do pokrycia użyto mięśni międzyżebrowych), samorozprężalny metalowy stent założono u 1 pacjenta. Ponadto u 1 pacjenta wykonano szycie prawego oskrzela głównego i przełyku, u 1 – *sleeve*-lobektomię lewą górną, u 1 – prawą górną lobektomię, u 3 założono stent silikonowy Y, u 1 przeprowadzono minitracheostomię, a u 5 chorych włączono leczenie zachowawcze.
Wnioski: Intubacja jest najczęstszą przyczyną urazów jatrogennych głównych dróg oddechowych. Pacjenci z powikłaniami zagrażającymi życiu wymagają indywidualnego podejścia oraz leczenia w ośrodkach referencyjnych.
Słowa kluczowe: tchawica, drzewo oskrzelowe, uraz jatrogenny.

Introduction

Iatrogenic injuries to the trachea and main bronchi are rare complications of invasive procedures. Most often they result from tracheal intubation, with frequency being reportedly 0.05-0.37% [1-3]. Risk factors are: emergency intubation, extra-hospital intubation and use of double-lumen tracheobronchial tubes. Other causes of iatrogenic airway injuries include:

- percutaneous tracheostomy,
- airway patency restoration using rigid bronchoscopy,
- mechanical ventilation,
- surgical procedures on the thyroid gland, oesophagus and lung.

Most published papers are case reports or small case series, and very few present collective reviews [4-7].

Diagnostic work-up includes history and physical examination with particular attention to subcutaneous emphy-

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sema in the neck, face and chest, coughing, haemoptysis, respiratory distress, pneumothorax and pneumomediastinum. Clinical examination is supplemented with chest radiogram and computed tomography (CT). The most important tool in confirmation of the diagnosis is bronchoscopy, enabling precise assessment of location, size and type of injury. The mainstay of treatment is surgical repair, although conservative treatment is increasingly popular in selected patients [8-12].

Material and methods

Retrospective analysis of hospital records of all patients treated for main airway injuries between 1990 and 2012.

Results

Characteristics of the analysed group

In the study period, 24 patients were treated for iatrogenic injuries to the trachea or main bronchi. There were 21 women (87.5%) with the mean age of 61 years (range: 17-84) and 3 men with the mean age of 52 years (range: 49-56). In 1 patient there was an injury in the cervical trachea and in the remaining 23 in the thoracic part of the airway.

Mechanism of injury and diagnostics

In 16 patients the injury occurred during tracheal intubation: in 7 it was located in the upper 2/3 of the trachea and in 9 in the lower segment. Injury resulted from rigid bronchoscopy in 1 patient, from oesophagoscopy in 1, from mediastinoscopy in 1 and was a complication of open surgery in 5 patients (4 oesophagectomies and 1 resection of oesophageal diverticulum). In 4 patients the laceration was located in the right main bronchus and in 2 in the left main bronchus.

All 16 injuries related to tracheal intubation happened in other hospitals and included intubation for gynaecological procedures, mastectomy, laparoscopic cholecystectomy and large bowel resection. In 13 patients injury occurred during elective intubation and in 3 during emergency extrahospital intubation.

Mean time between injury and bronchoscopic confirmation of the diagnosis was 12 hours (range: 2-48). The most frequent sign was subcutaneous emphysema, followed by haemoptysis, coughing, and neck or chest pain. In all patients chest radiogram and CT were obtained on admission to check for pneumomediastinum and mediastinitis, pneumothorax and/or hydrothorax and pneumonia, as well as to gain more detailed information on anatomy. Next, bronchoscopy was performed with assessment of the location, size and depth of injury. Oesophagoscopy was also performed to exclude tracheo-oesophageal fistula.

The remaining 8 airway injuries occurred in the authors' institution. The mechanism was rigid bronchoscopy in 1 patient, rigid oesophagoscopy in 1, mediastinoscopy in 1 and open surgery in 5 patients (oesophagectomy in 4 and oesophageal diverticulum resection in 1). In all cases injury was diagnosed during the procedure and time elapsed until the decision regarding further treatment was < 2 hours.

In 12 patients the length of the tear was 1.5-3 cm, in 10 it was 3-5 cm, and in 2 patients it was 5-8 cm.

Treatment and results

The method of treatment was surgical repair in 14 patients, airway stenting in 4, mini-tracheostomy in 1 and conservative treatment in 5 patients. The mean time of hospital stay was 9.25 days (range: 1-15 days).

In 10 patients emergency surgery was necessary due to progressive respiratory insufficiency, pneumomediastinum and pneumothorax. In all these cases direct repair via right postero-lateral thoracotomy was performed. Interrupted PDS 3-0 sutures were used to close the tear, and in 1 patient the repair was additionally covered with a pedicled intercostal flap. Suction drainage of the posterior mediastinum and the pleural cavity was routinely used. In all patients on-table bronchoscopy was performed to assess tightness of the repair and to clear secretions. Patients were routinely transferred to the intensive care unit, and bronchoscopy was regularly performed in order to clear bronchial secretions. Broad-spectrum antibiotics and mucolytics were administered.

In 1 patient suture of a 2 cm tear in the left main bronchus and the oesophagus was performed with interrupted PDS 3-0 sutures and Ethibond 2-0 sutures.

In 1 patient with injury to the right main bronchus and with high operative risk due to sepsis and renal insufficiency, a self-expanding Areo DV stent (Merit Medical) was used.

In 3 patients with distal tracheo-bronchial injuries (in 1 with associated oesophageal injury) a silicone Y stent (Demed Mikołów) was successfully used. These stents were removed between the 7^{th} and 10^{th} day after injury.

In 1 patient with cervical tracheal injury a mini-tracheostomy was performed.

Mortality in the whole group was 16.7% (4 of 24 patients). All deaths were noted in patients in poor general condition and with severe comorbidities. Two of them were admitted after cardiac arrest and resuscitation – one with severe stroke and renal insufficiency and the second one with ischaemic brain damage on admission. Two patients with bronchial injuries developed severe sepsis in multiorgan failure following oesophageal resection.

No complications related to the airway injury were noted in the remaining 20 patients, although one of them had severe neurological deficit due to cardiac arrest at home and prolonged brain ischaemia; in this patient tracheal repair was successful, but her neurological status did not improve.

In all survivors the follow-up bronchoscopy at 3 months after treatment confirmed complete healing and good patency of the airway.

Discussion

Iatrogenic airway injuries related to tracheal intubation are rare, with the incidence of 0.05-0.37% [1-3, 7, 13].

According to Schneider *et al.*, the incidence is 1/75 000 for standard tube intubation, 5-19/10 000 for double-lumen tube intubation, and 1/575 for percutaneous tracheostomies [7]. However, the real incidence is difficult to assess due to the relatively small number of cases published. Intubation-related injuries occur particularly often during repeated attempts of intubation and if the guide-wire is used, protruding out of the distal end of the tube. Other risk factors include obesity, age > 50 years, physician's limited experience and re-positioning of the tube with the inflated balloon [6, 10]. Also, steroid therapy and any pathology within the trachea or in its surroundings, i.e. tumours, adenopathy, tracheitis, bronchomalacia, tracheal stenosis, chronic obstructive pulmonary disease, kyphosis or kyphoscoliosis, may increase the risk of tracheal injury [6, 14, 15].

The clinical picture includes subcutaneous emphysema in the neck, face and chest, dyspnoea, coughing, haemoptysis, pneumomediastinum and pneumothorax [4, 6, 8-10, 16-18].

There is no consensus regarding the treatment of iatrogenic airway injuries [6-8, 11, 17, 19, 20]. However, several authors agree on the following criteria of conservative treatment: good general condition, haemodynamic and respiratory stability, limited tear in the upper trachea, no signs of mediastinitis, and no progressive subcutaneous emphysema or pneumomediastinum [6, 8, 10, 21]. Other authors consider the length and depth of injury as the most important criteria of conservative treatment [5, 17, 22]. However, this is not contradictory, as deep lacerations are usually associated with progressive pneumomediastinum, mediastinitis and respiratory failure. Cardillo *et al*. proposed a 4-grade morphological classification of intubation-related tracheal injuries:

- Grade I: tear limited to mucosa or submucosa, no pneumomediastinum or mediastinitis;
- Grade II: tear of the membranous part with subcutaneous emphysema and/or pneumomediastinum, no oesophageal injury or mediastinitis;
- Grade IIIA: full disruption of the tracheal wall, no oesophageal injury or mediastinitis;
- Grade IIIB: any tracheal injury associated with oesophageal injury or mediastinitis [17].

In patients with grade I-IIIA injuries, Cardillo *et al.* used conservative treatment including bronchoscopic application of 1-2 ml fibrin glue to seal the injury. A similar technique was also adopted by Hofmann *et al.* [5]. According to Cardillo *et al.*, in patients with grade IIIB injuries surgical repair via right thoracotomy should be performed, supplemented with broad-spectrum antibiotics, anti-cough medication and parenteral nutrition.

Minambres *et al.* published a systematic review of 182 cases from 50 original papers [6]. There was a strong predominance of women (85.7%), which corresponds to the structure of our group. Elective intubation was the cause of injury in 65.9% of patients, emergency intubation in 27.4%, and in the remaining 12 patients no data in this regard were available. As the number of elective intubations largely exceeds the emergency ones, the results confirm very high risk of tracheal injury associated with emergency intubation. In 53.3% of cases a single-lumen tube was used, and in the remaining 46.7% a double lumen tube. Again, due to the relatively small number of intubations with double-lumen tubes, the results confirm the high risk associated with their use. In 17% of patients, injury was diagnosed during the procedure and in the remaining 83% with a delay of up to 240 hours. The length of tear was 5-130 mm. The most common symptoms included subcutaneous emphysema (64%), followed by pneumomediastinum, pneumothorax, dyspnoea and haemoptysis. These data also correspond well with our results. Overall mortality was 22%, which is similar to our data (16.7%). Emergency intubation, advanced patient age and delay in diagnosis were associated with increased mortality. According to other authors, factors increasing mortality include delay in diagnosis > 20 hours, difficult intubation, age > 60 years, female gender and obesity [10, 19]. In our group, 2 patients died within the first 24 hours; both underwent emergency extra-hospital intubation due to cardiac arrest and had severe neurological pathology. The remaining two patients in our group died due to severe sepsis and multi-organ failure after oesophageal resection. The direct cause of all deaths in our group was not related to the airway injury. In the study of 19 patients with iatrogenic airway injuries, Hofmann reported mortality of 42% [5].

Regarding conservative treatment, the results presented by Minambres are in concordance with other authors, who believe that it should be used in cases of small lacerations and with no progressive general symptoms [8, 9, 11, 21]. Our results support this point of view.

Stenting is relatively seldom used in the treatment of airway injuries. Yopp *et al.* used a self-expanding stent for 4 cm laceration of the membranous part of the trachea [18]; a similar stent was used in one of our patients. Self-expanding metallic stents are not widely used, because they cause damage to the airway mucosa and their removal is difficult. We also implanted a silicone Y stent in 2 patients with laceration of the membranous part of the lower trachea. The treatment was successful and the stents were removed on the 7^{th} and 10^{th} day; follow-up bronchoscopy confirmed healing of the laceration. A third Y stent was successfully used in a patient with injury to the right main bronchus and the oesophagus. Our results with airway stenting in patients with iatrogenic injuries to the trachea and main bronchi are similar to those reported by other authors [18, 23]. Most authors agree that open surgical repair is required in case of full-thickness airway injury with pneumothorax, pneumomediastinum, progressive respiratory insufficiency or technical difficulties in ventilation [4, 5, 15, 19, 22, 24], whilst stenting should be used in medically inoperable patients [18, 23].

In order to limit surgical trauma, some authors advocate the use of minimally invasive techniques [12, 20, 24, 25]. Welter presented endoscopic repair of lacerations of

the membranous part of the trachea using a videotracheoscope and endoscopic instruments, with general anaesthesia and jet ventilation. Endoscopic repair was attempted in 4 patients, with one conversion to open repair. Videobronchoscope-assisted repair of tracheal laceration was presented by Okada *et al.* [20]. Minimally invasive endoscopic techniques were not used in our group.

Conclusions

Intubation is the most frequent cause of iatrogenic main airway injuries. Patients with such complications require an individualised approach and treatment in a reference centre. Conservative management can be safely used in a well-selected group of patients. Mortality is mostly associated with severe comorbidities.

Disclosure

Authors report no conflict of interest.

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