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WJO covers topics concerning arthroscopy, evidence-based medicine, epidemiology, nursing, sports medicine, therapy of bone and spinal diseases, bone trauma, osteoarthritis, bone tumors and osteoporosis, minimally invasive therapy, diagnostic imaging. Priority publication will be given to articles concerning diagnosis and treatment of orthopedic diseases. The following aspects are covered: Clinical diagnosis, laboratory diagnosis, differential diagnosis, imaging tests, pathological diagnosis, molecular biological diagnosis, immunological diagnosis, genetic diagnosis, functional diagnostics, and physical diagnosis; and comprehensive therapy, drug therapy, surgical therapy, interventional treatment, minimally invasive therapy, and robot-assisted therapy.

We encourage authors to submit their manuscripts to *WJO*. We will give priority to manuscripts that are supported by major national and international foundations and those that are of great basic and clinical significance.

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Retrospective Study

Emergent reintubation following elective cervical surgery: A case series

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Author contributions: Schroeder J designed and performed the research, analyzed the data and wrote the paper; Salzmman SN analyzed the data and wrote the paper; Hughes AP designed the research and provided clinical advice; Beckman JD designed the research and provided clinical advice; Shue J analyzed the data and provided research advice; Girardi FP designed the research and provided clinical advice.

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Informed consent statement: For the patients presented in this case series, a waiver of patient informed consent and U.S. Health Insurance Portability and Accountability Act (HIPAA) authorization were sought. Information contained in this case report contains no personal identifiers to ensure patient confidentiality and protections. Under these provisions, the Institutional Review Board (IRB) at our institution provided approval of this study (IRB#2014-062).

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Abstract

AIM

To review cases of emergent reintubation after cervical surgery.

METHODS

Patients who were emergently intubated in the post-operative period following cervical surgery were identified. The patients' prospectively documented demographic parameters, medical history and clinical symptoms were ascertained. Pre-operative radiographs were examined for the extent of their pathology. The details of the operative procedure were discerned.

RESULTS

Eight hundred and eighty patients received anterior- or combined anterior-posterior cervical surgery from 2008-2013. Nine patients (1.02%) required emergent reintubation. The interval between extubation to reintubation was 6.2 h [1-12]. Patients were kept intubated after reintubation for 2.3 d [2-3]. Seven patients displayed moderate postoperative edema. One patient was diagnosed with a compressive hematoma which

was subsequently evacuated in the OR. Another patient was diagnosed with a pulmonary effusion and treated with diuretics. One patient received a late debridement for an infected hematoma. Six patients reported residual symptoms and three patients made a complete recovery.

CONCLUSION

Respiratory compromise is a rare but potentially life threatening complication following cervical surgery. Patients at increased risk should be monitored closely for extended periods of time post-operatively. If the airway is restored adequately in a timely manner through emergent re-intubation, the outcome of the patients is generally favorable.

Key words: Cervical surgery; Complication; Airway compromise; Reintubation; Hematoma

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Core tip: The rate of cervical spine surgery has increased over the last years. Airway compromise is a rare but potentially life threatening complication following this type of procedure. This case series represents a single institution's experience of 9 cases requiring emergent reintubation after anterior- or combined anterior-posterior cervical spine surgery. Besides reporting patient characteristics and operative details, our approach to evaluating and treating these cases is presented. In addition the literature addressing reintubation after cervical spine surgery is reviewed.

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INTRODUCTION

Degenerative conditions of the cervical spine result from disk degeneration and the subsequent osteophytic bone formation extending along the affected vertebrae^[1-3]. The uncinat processes as well as the ligamentum flavum may hypertrophy^[1]. All of these mechanisms constitute the body's natural response to restore stability and alignment of the cervical spine. Less commonly, cervical kyphosis, compensatory subluxation and the ossification of the posterior longitudinal ligament are factors which may contribute to a progression of the disease resulting in a wide spectrum of clinical signs and symptoms^[4].

Overall, up to 89%-95% of men and women aged 60 and above will have degenerative changes visible in their cervical spine imaging, C5-6 being the most commonly affected level^[5-7]. Dependent on the degree of nerve root- and spinal cord compression, patients may present with

neck pain, radiculopathy or paresthesias of the upper extremities, or signs of myelopathy such as gait- and fine motor control impairment and weakness^[8,9]. In cases of myelopathy, severe radicular pain, and patients with progressive neurologic deficits, cervical spine surgery is performed as these patients generally have debilitating sequelae^[10].

The safety profile of cervical spine surgery is high, however a mortality rate of 0.14% and an incidence of major complications of 3.93% have been associated with cervical surgery. Patient age > 74 years, a primary diagnosis of cervical spondylosis with myelopathy and large cervical procedures such as long posterior fusions or combined anterior and posterior fusion were found to be predictive of an increased risk of complications^[11].

A more dangerous complication is breathing insufficiency, resulting in urgent reintubation. It has been reported in 0.14%-1.9% of patients undergoing cervical surgery^[12-14]. Postoperative reintubation has been correlated with advanced age, chronic pulmonary disease, pre-operative hypoalbuminemia and anemia, recent weight loss, a high serum creatinine, three or more cervical levels operated on and prolonged surgical time^[12-15]. As urgent reintubation is a lifesaving procedure, timely management is critical in order to avoid grave morbidities and mortalities.

We present a detailed case series of a single institution's experience with postoperative reintubation in patients receiving anterior- or combined anterior-posterior cervical surgery.

MATERIALS AND METHODS

Study population

Data was reviewed from a prospectively maintained hospital database of 880 patients who underwent cervical spine surgery over a 5 year period (2008-2013) at a single institution. Nine patients that required emergent postoperative reintubation following previous extubation were identified.

Data collection

Data was retrospectively collected on patient demographics, past surgical- and medical history, evidence of osteopenia or osteoporosis, primary diagnosis, and surgical details. Data was collected using intra-operative and discharge reports through SRS (SRSsoft, Montvale, NJ, United States). The patients prospectively documented clinical findings and the diagnostic details of their pre-operative imaging were recorded.

RESULTS

The incidence of emergent reintubation following anterior- or combined anterior-posterior cervical surgery was found to be 1.02%.

Patient characteristics

Detailed patient parameters are presented in Table 1. The

Table 1 Patient demographic parameters

No.	Gender	Age (yr)	BMI	Smoking Status	Comorbidities
Case 1	Male	53	29.3	Never	Hyperlipidemia
Case 2	Female	70	26.7	Never	hypertension, Von willebrand disease, hypoglycemia, visual migraines
Case 3	Male	44	23.7	Current, 15 P-Y	-
Case 4	Male	58	26.5	Former, 15 P-Y	Diabetes mellitus type I , asthma
Case 5	Female	58	22.9	Never	Rheumatoid arthritis, hypertension, GERD
Case 6	Male	56	27.7	Never	Coronary artery disease, hypertension, benign prostate hyperplasia
Case 7	Female	71	29.3	Current, 8 P-Y	COPD, pulmonary hypertension, obstructive sleep apnea, GERD
Case 8	Female	51	25.6	Never	-
Case 9	Female	61	21	Never	GERD

P-Y: Pack-years; GERD: Gastroesophageal reflux disease; BMI: Body mass index; COPD: Chronic obstructive pulmonary disease.

average age of the patients was 58 [44-71]. The average BMI of the patients was 25.86 [21-29.3]. The male to female ratio was 4:5. Three patients had a history of tobacco consumption, with two patients remaining active smokers with an average number of 11.5 pack years [8-15]. The patients' medical histories were significant for systemic heart disease in five patients, and for pulmonary disease in two patients. One patient suffered from rheumatoid arthritis. Overall, five patients had multiple systemic comorbidities. One patient's surgical history was significant for a prior emergent posterior cervical decompression from C2-5 for a spontaneous epidural hematoma.

Initial evaluation and diagnostic studies

Five patients complained of myelopathic gait changes. Neck pain was the main complaint of four patients, with three patients each reporting additional shoulder pain or paresthesias. Two patients suffered from upper extremity weakness and numbness, whilst one patient each complained a loss of fine motor control and arm- or hand pain. 8 patients exhibited evidence of a cord signal change in their MRIs.

Initial surgical management

Operative details are presented in Table 2. The average length of surgery was 7.67 h [4.5-11.5], with an average of 3.78 cervical levels fused [2-6]. Three cases were combined anterior and posterior cervical surgeries. The average estimated intraoperative blood loss was 639 mL [150-1100]. No intra-operative complications were recorded in any of the patients. Four patients were kept intubated after completion of the case and extubated on average on the postoperative day number 2 [1-4]. Five patients were extubated at the end of the case. All patients were kept in the post-anesthesia care unit after surgery to monitor airway compromise.

Respiratory distress diagnosis and intervention

Details on postoperative airway management are presented in Table 3. The average interval between extubation to reintubation was 373.3 min [60-720]. The symptoms leading to a pulmonary reevaluation and emergent reintubation varied. Four patients presented with progressive onset of dyspnea, in some cases in combination with stridor,

dysphagia or dysphonia. Three patients had no physical complaints but developed hypoxemia with an oxygen saturation ranging from 70%-80%. Two patients developed a spontaneous severe cough. One of the patients was still intubated and inadvertently extubated himself whilst convulsively coughing, leading to his emergent reintubation.

In general, patients were reintubated nasally after topical lidocaine using a flexible fiberoptic bronchoscope to allow for assessment of airway swelling and vocal cord function. Reintubations were easily performed, however, all were done by experienced attending anesthesiologists. None of the patients required tracheostomy for initial reintubation.

The patients were kept intubated after their emergent reintubation for a mean of 2.3 d [2-3]. Urgent fibroscopic ENT examination and imaging identified a compressive hematoma in one patient that was evacuated in the OR. One patient was diagnosed with pulmonary edema and subsequently desaturated and was transferred to the intensive care unit. The remaining seven patients showed no clear signs of respiratory obstruction, with only moderate pharyngeal edema being identified in diagnostic imaging. Due to the severity of their symptoms, four of the patients with this diagnosis received decadron - three of them in combination with racemic epinephrine.

Follow-up

The patients were followed for an average 21.7 mo [2-26.9]. Residual complaints are summarized in Table 4. One patient who was not diagnosed with a hematoma upon emergent airway reevaluation leading to reintubation required a late debridement for an infected hematoma. Three patients made a complete recovery. The remaining six patients reported residual primary complaints of neck pain, paresthesias, numbness and radicular pain. One patient reported a new onset of headaches. None of the patients complained of persistent dysphagia or dysphonia. Overall, none of the patients experienced any clinical sequelae of their reintubation.

DISCUSSION

In this series of 880 patients undergoing cervical surgery, the overall incidence of emergent reintubation following anterior- or combined anterior-posterior cervical surgery was 1.02%.

Table 2 Primary operative details

No.	Cord signal change (MRI)	Symptoms	Operated levels	Approach	Operative time (min)	Estimated blood loss (mL)
Case 1	Yes	Neck- and hand pain, gait change, paresthesias	C3-7	Anterior	360	750
Case 2	Yes	Upper extremity weakness, shoulder pain, paresthesias	C2-6	Combined	690	750
Case 3	Yes	Right arm pain	C3-7	Anterior	390	850
Case 4	Yes	Shoulder pain, paresthesias	C3-7	Anterior	570	800
Case 5	Yes	Gait change, numbness, weakness	C4-T3	Combined	600	950
Case 6	Yes	Neck pain, numbness, gait change	C3-7	Anterior	330	300
Case 7	Yes	Neck pain, gait change	C2-T6	Combined	660	1100
Case 8	No	Neck pain, shoulder pain	C4-6	Anterior	270	150
Case 9	Yes	Neck pain, shoulder pain, gait change, decreased fine motor control	C3-7	Anterior	270	100

MRI: Magnetic resonance imaging.

Table 3 Postoperative airway management

No.	Primary post-op extubation (d)	Time to reintubation (min)	Symptoms preceding reintubation	Diagnosis	Length of reintubation (d)	Therapeutic measures
Case 1	1	360	Dyspnea, stridor	Pharyngeal edema	2	Decadron
Case 2	1	600	Hypoxemia (70%)	Hematoma	3	Surgical evacuation
Case 3	0	60	Coughing white, thick mucous	Pulmonary edema	2	Decadron, epinephrine, diuretics
Case 4	0	60	Hypoxemia (80%)	Pharyngeal edema	3	-
Case 5	1	600	Dyspnea, stridor	Pharyngeal edema	3	Decadron, epinephrine
Case 6	0	60	Coughing whilst intubated: Inadvertently extubated	Pharyngeal edema	2	-
Case 7	4	720	Hypoxemia (70%-80%)	Pharyngeal edema	2	-
Case 8	0	420	Dyspnea, dysphagia, dysphonia	Pharyngeal edema	2	-
Case 9	0	480	Dyspnea	Pharyngeal edema	3	Decadron, epinephrine

The early signs and symptoms of airway compromise varied. Some patients developed a spontaneous severe cough, progressive dyspnea, stridor, dysphagia or dysphonia. However, some patients had no apparent physical complaints but developed hypoxemia, leading to reintubation. The timely diagnosis of the airway compromise and the subsequent management thereof resulted in a lack of longterm morbidity and mortality related to the complication. Pharyngeal edema was the leading pathology causing postoperative airway compromise.

Postoperative airway compromise is a rare complication of anterior- or combined anterior-posterior cervical surgery. Nandyala *et al.*^[15] examined 8648 patients from the American College of Surgeons National Surgical Quality Improvement Program database. They found that 0.62% of patients analyzed in their study who had undergone cervical spine surgery required prolonged ventilation. An additional 0.64% was reintubated postoperatively. Emergent reintubation was correlated with advanced age and a greater comorbidity burden, demonstrating

similar findings as our case series. Marquez-Lara *et al.*^[12] examined a patient sample which underwent anterior cervical surgery from the Nationwide Inpatient Sample database. They reported an incidence of reintubation of 0.56% and reaffirmed the correlation of reintubation with old age and an increased comorbidity burden. Additionally, they reported a correlation with fusions of three or more levels. Hart *et al.*^[16] experienced a high postoperative incidence of airway edema requiring continuous intubation or emergent reintubation in 45% of cervical surgeries crossing the cervicothoracic junction. All but one of the patients presented here demonstrate at least one of the risk factors reported in the literature such as multi-level fusions, pulmonary disease, advanced age or prolonged surgical time^[12-15].

A variety of conditions have been implicated as the cause of postoperative airway compromise in cervical surgery. Emery *et al.*^[17] presented a series of seven patients who required emergent reintubation following upper-airway compromise after multi-level corpectomies

Table 4 Follow-up

No.	Residual complaints
Case 1	Persistent neck pain and numbness
Case 2	Trapezius pain, paresthesias
Case 3	Residual neck pain
Case 4	-
Case 5	-
Case 6	-
Case 7	Intermittent neck pain, radiculopathy of the right arm
Case 8	Not reported
Case 9	Intermittent neck pain, paresthesias, headaches, numbness and paresthesias of the left thumb and index finger

for myelopathy with a mortality rate of 28.6%. They believed that the cause of the conditions was predominantly hypopharyngeal and supraglottic swelling. Additional studies have discussed their experience with retropharyngeal postoperative hematoma, cerebrospinal fluid collection, angioedema and hardware dislodgement as causes of respiratory distress^[18-22]. The point in time at which the airway compromise occurs has been described as a possible indicator of the etiology. Wound hematomas and pharyngeal edema normally occur within the first hours after the procedure, while respiratory compromise after three days indicates pathologies including abscess formation, cerebrospinal fluid leak or hardware failure^[23]. An optimization of inter-departmental cooperation and the capability of emergent imaging may expedite the diagnosis, resulting in a timely intervention and re-establishment of airway control. In our case series, the diagnosis was made with the help of ear, nose, and throat specialists evaluating the patients combined with an emergent intubation by trained anesthesiologists. Seventy-seven point seven percent of the patients requiring reintubation were subsequently diagnosed with a radiographically not impressive pharyngeal edema. This finding is concurrent with the reports found during our review of the literature.

Few studies discuss the treatment or prevention of airway compromise. Hart *et al*^[16] examined the effect of the implementation of a fluid management protocol in cervical surgery crossing the cervicothoracic junction. They found that none of the patients who received limited intraoperative fluid resuscitation with crystalloids and a maintenance of constant blood pressure after the implementation of the protocol experienced postoperative airway compromise vs the 45% of patients who had experienced complaints previously. We found that our strict adherence to hospital protocol of keeping the patient in the step down unit for 24 h, uninterrupted postoperative monitoring of the vital signs of the patient, as well as continuous regular examinations of the patient contributed to prompt airway management resulting in a lack of mortality amongst these patients.

Sabaté *et al*^[24] examined the implications of post-operative pulmonary complications and reported an increased incidence of mortality, length of stay, readmissions,

and costs. Our case series gives a limited account of the clinical progression of the patients as well as long term follow up examining the clinical sequelae of their complication. It lacks an analysis of risk factors or a prospective examination of the pathophysiology of the complication. Given the overall increases in cervical surgery over the past years due in part to the aging population and novel technological developments, the clinical as well as the economic burden of this potentially life-threatening complication merits more detailed examination^[25]. This is also important since an increasing number of cervical spine surgeries are being performed in the outpatient setting^[26,27].

In conclusion, careful monitoring, timely intervention, and a standardized protocol of intervention in patients with respiratory failure after cervical surgery can provide patients with a favorable long term outcome. Extended care in a monitored environment is recommended for multi-level anterior and anterior posterior complex cervical cases.

COMMENTS

Background

The rate of cervical spine surgery has increased over the last years. Airway compromise is a rare but potentially life threatening complication following this type of procedure.

Research frontiers

There is a paucity of literature on incidence, risk factors and management of postoperative airway compromise following cervical spine surgery.

Innovations and breakthroughs

The incidence of emergent reintubation following anterior- or combined anterior-posterior surgery was found to be 1.02%.

Applications

Patients at increased risk should be monitored closely for extended periods of time post-operatively.

Peer-review

The authors present a detailed paper on reintubation after cervical surgery. This is an important issue as reintubation frequency is in literature less than 1% of the cases. They give valuable information of the seven cases in several tables, combining that important information with a very concise paper, ending in useful conclusions. Therefore this is a very interesting, well-written and succinct paper.

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