

Clinical Article

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Relations between Airway Narrowing and Prevertebral Soft Tissue Swelling after Anterior Cervical Spine Surgery : The Value of Lateral Neck Radiographs

Objective : The authors attempted to evaluate the pattern of the airway narrowing due to prevertebral soft tissue swelling after surgery of the anterior cervical spine and their clinical significances using plain cervical X-ray images.

Methods : Twenty-four patients undergoing anterior cervical spine surgery were reviewed from January 2004 to December 2005. Postoperatively, in daily basis, lateral radiograph of the neck was obtained in neutral position. We measured the upper airway diameter above and below the epiglottis level and prevertebral soft tissue diameter everyday for a week and finally 2 weeks after surgery using their simple lateral cervical X-ray films.

Results : Both airway narrowing and prevertebral soft tissue swelling were maximum in postoperative 2 days, and decreased rapidly in postoperative 7 days. Airway narrowing was aggravated postoperatively but slowly decreased as prevertebral soft tissue swelling diminished. But, the severity of airway narrowing showed no clinical correlations with clinical symptom and radiologic severity.

Conclusion : Not all patients who show severe airway narrowing and prevertebral soft tissue swelling on their plain cervical X-ray film complain respiratory insufficiency. But, the patients with undergoing anterior cervical spine surgery should be monitored carefully for respiratory insufficiency, especially during several days following operation because both airway narrowing and prevertebral soft tissue swelling become peak at postoperative 2-3 days.

KEY WORDS : Soft tissue · Airway obstruction · Respiratory insufficiency.

INTRODUCTION

Anterior approaches to the cervical spine for decompression, fusion or instrumentation are common for many conditions including degenerative diseases^{2,4,14,16,20,21}. One of the rare but serious complications from the anterior cervical approach is respiratory insufficiency as a result of upper airway obstruction probably due to airway narrowing and prevertebral soft tissue swelling^{2,3,8,10,13,15,16,18,22,24}. There are many image modalities to evaluate prevertebral soft tissue swelling and airway narrowing including MRI, CT scan, simple X-ray and others. Among this, simple X-ray can be easily taken and not expensive compared to MRI or CT scan^{6,7}. The objective of this study is to evaluate the pattern of the prevertebral soft tissue swelling and degree of airway obstruction using simple X-ray images. We also investigated the patient's respiratory symptoms who had airway narrowing after anterior cervical spine surgery and their clinical significances.

MATERIALS AND METHODS

Twenty-four patients were undergone anterior cervical spine surgery from January 2004 to December 2005. We excluded traumatic cervical injury patients because it was possible they already had preoperative prevertebral soft tissue swelling and contusion due to trauma^{1,9,12,15,19}. All of them had degenerative cervical spinal diseases and underwent anterior cervical disectomy and fusion (ACDF). There were 12 men and 12 women and the age ranged between 36 and 70 (mean 51.2 years). All patients underwent 1 level cervical spine surgery with various fixation plate, 16 patients PCB plate, 6 patients ZENITH plate, 1 patient

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AMSLU cage, 1 patient ORION plate (Table 1). The lateral cervical radiographs in the neutral position were taken preoperatively, immediately postoperatively, and then daily for 7 days after the operation, and finally 2 weeks after surgery^{1,5,7,9}. We measured the upper airway diameter above and below epiglottis level and prevertebral soft tissue diameter using their simple lateral cervical X-ray films (Fig. 1). The prevertebral soft tissue thickness was measured as ratio of vertebral body's anterior-posterior (AP) diameter and distance from anterior margin of prevertebral soft tissue to posterior margin of vertebral body at the level of anterior arch of C1, anteroinferior edge of C2, C3, C5, C6, C7 and anterosuperior edge of C4^{11,19}. The patient's medical history was obtained from a chart review. There were some expressions related to respiratory problem, dyspnea, respiratory discomfort, respiratory difficulty, respiratory insufficiency. All of these expressions are not separately used in each case because all cases with dyspnea were not severe. We performed a analysis of variance (ANOVA) test to assess the relationship between each parameter and the respiratory insufficiency by use of statistical program SPSS® 12.0.

RESULTS

The complications after surgery

After surgery, 7 patients presented respiratory difficulty (29%), 3 patients presented odynophagia (12.5%), 1 patient cerebrospinal fluid (CSF) leakage (4.2%), 1 patient metal loosening (4.2%). Among these complicated patients, all except the patient with metal loosening improved symptom spontaneously. The patient with metal loosening was taken reoperation. But, remaining were all mild cases and needed no more medical procedure. All of 7 patients presenting respiratory difficulty complained their clinical symptom before 4 days after surgery. But, none of them needed endotracheal intubation to sustain airway. Patients with no significant respiratory problem experienced respiratory difficulty sustained no longer 3 days after its appearance. There were no preoperative medical problems related to pulmonologic and otorhinolaryngologic systems in any of these patients.

Table 1. Summary of patients who underwent anterior cervical spine surgery

Case	Sex	Age	Diagnosis	Level	Op time(Min)	Instrument	Complications
1	F	47	HNP	C4-5	100	PCB	None
2	M	47	HNP, OPLL	C4-5	150	ZENNITH	None
3	M	47	HNP, OPLL	C4-5	120	ZENNITH	Swallowing difficulty
4	F	55	HNP	C6-7	120	PCB	Dyspnea
5	F	66	HNP	C5-6	150	PCB	Dyspnea
6	F	42	HNP	C4-5	100	PCB	None
7	M	43	HNP	C4-5	120	PCB	None
8	M	41	HNP	C5-6	150	PCB	None
9	F	60	HNP	C7-T1	150	PCB	None
10	M	70	HNP	C5-6	140	PCB	Dyspnea
11	F	65	HNP	C5-6	130	PCB	None
12	M	59	HNP	C4-5	100	PCB	None
13	M	52	HNP	C5-6	140	PCB	None
14	F	36	HNP	C6-7	130	PCB	None
15	F	40	HNP, OPLL	C5-6	240	ORION	Swallowing difficulty
16	M	58	OPLL	C6-7	300	ZENNITH	CSF leakage
17	M	57	Stenosis	C4-5	150	ZENNITH	None
18	F	46	HNP	C4-5	120	AMSLU	None
19	M	57	Stenosis	C5-6	160	ZENNITH	Dyspnea, Metal loosening
20	M	57	Stenosis	C5-6	150	ZENNITH	Dyspnea, Swallowing difficulty
21	F	41	HNP	C5-6	150	PCB	Dyspnea
22	F	42	HNP	C6-7	120	PCB	Dyspnea
23	F	50	HNP	C6-7	135	PCB	None
24	M	51	HNP	C3-4	150	PCB	None

The radiologic changes of airway caliber and prevertebral soft tissue swelling after surgery

Airway narrowing was maximum on 2nd day or 3rd postoperative day and diminished gradually during 2 weeks after surgery (Fig. 2). Degrees of airway narrowing showed no significant difference between above and below epiglottis (Fig. 3). Average value of airway above epiglottis changed preoperative 13.8mm to 9.51mm at postoperative 2days. Similarly, average value of airway below epiglottis preoperatively were 14.3mm,

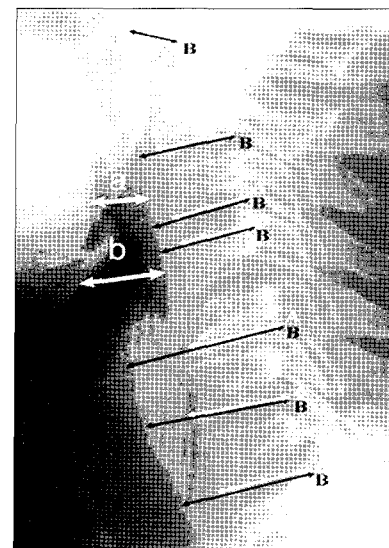


Fig. 1. The method of measurement of width of the airway caliber and prevertebral soft tissue swelling by use of the cervical lateral X-ray film. Airway caliber is measured at the level of above and below epiglottis (a and b). Prevertebral soft tissue is measured as ratio of vertebral body's AP diameter and distances from anterior margin of prevertebral soft tissue to posterior margin of vertebral body (B/A).

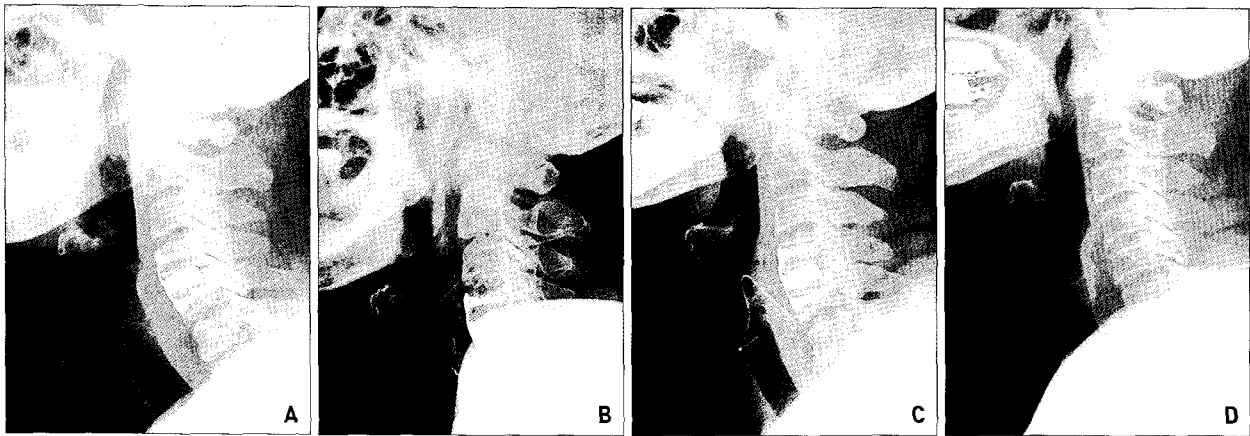


Fig. 2. Radiologic change of the prevertebral soft tissue serially after surgery (A : Preoperative image, B : immediate after operation, C : postoperative 2 days, D : postoperative 7 days). Note that prevertebral soft tissue has become thickened and airway caliber gradually shortened postoperatively (A, B, C), and improved at the 7th day of operation (D). Most of cases in our study, the pattern of airway narrowing and prevertebral soft tissue swelling show similar natural time course as shown in this figure.

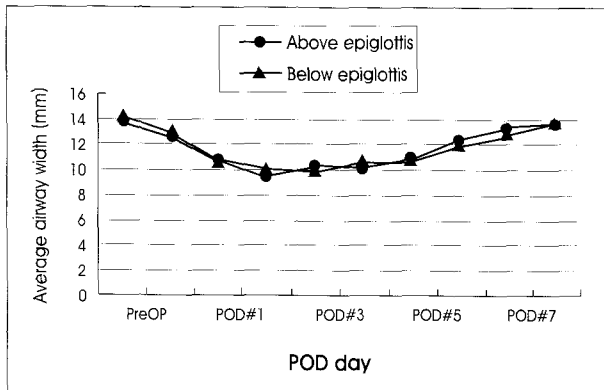


Fig. 3. The graph of average airway narrowing measured at the level of above epiglottis and below epiglottis. Note that maximal airway narrowing is at postoperative second day. Airway narrowing gradually disappeared and two groups (upper epiglottis and below epiglottis) showed no significant differences.

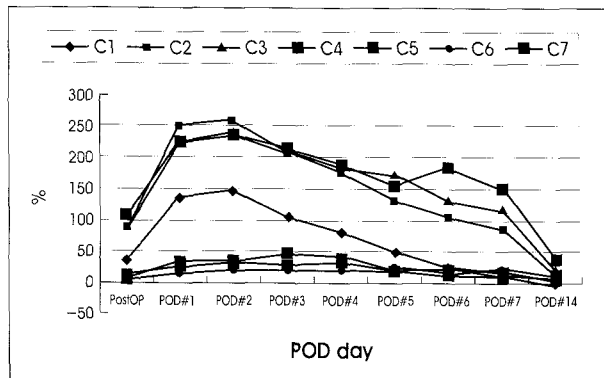


Fig. 4. The graph of percentage of soft tissue swelling after anterior cervical spine surgery, compared to its preoperative state. Prevertebral soft tissue swelling is maximum at postoperative 2nd day and upper cervical soft tissue swelling (C1, C2, C3, C4) is more dominant than that of lower cervical soft tissue (C5, C6, C7).

10.2 mm at 2nd day of operation, 10.1 mm at 3rd day of operation. Prevertebral soft tissue swelling was also maximum at second postoperative day and diminished to normal caliber

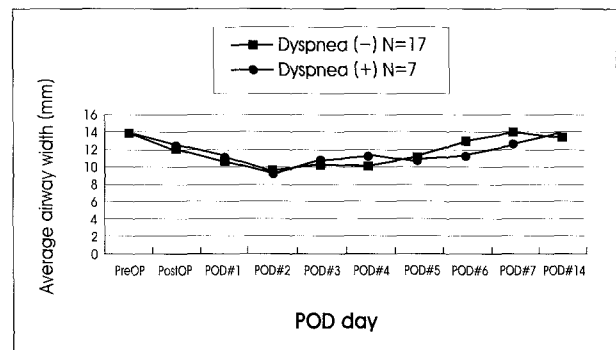


Fig. 5. The graph of average airway width in patients presenting dyspnea and without dyspnea after anterior cervical surgery. Two groups show no significant differences in their airway caliber.

after 2 weeks postoperatively similar to airway narrowing (Fig. 4). Particularly, the upper cervical prevertebral soft tissue (C1, C2, C3, C4) swellings were more severe than lower cervical spine soft tissue (C5, C6, C7). C1 showed 147.5% swelling at 2nd postoperative day compared to preoperative status; C2 258.6%, C3 239.4%, C4 236.1%. Contrary to these, C5 showed 29.6% swelling, C6 18%, and C7 32.9%.

Clinical correlation of patient symptoms with radiologic findings

In patients who had newly developed respiratory problem postoperatively, compared with those who had not, there were no different patterns and severities of airway narrowing and prevertebral soft tissue swelling (Fig. 5). The airway diameter of patients with dyspnea showed average 13.7 mm preoperatively, 9.3 mm at 2nd operation day. The group without dyspnea showed an average 13.8 mm preoperatively to 9.6 mm at 2nd operation day.

There was no correlation between the respiratory difficulty or insufficiency and radiologic airway narrowing (p=0.16).

Airway narrowing has a close relation with female ($p=0.09$), above age 50-year-old ($p=0.08$), more than 150 minutes operation time ($p=0.08$). But, there's no meaningful correlation with instrumentation ($p>0.15$).

DISCUSSION

Acute airway obstruction is a rare event but potentially lethal complication after anterior cervical spine surgery^{2,3,8,10,13,17,18,22,23}. However, airway obstruction after anterior cervical spine surgery has not been prospectively investigated, probably because of the low incidence of acute airway obstruction in these cases. Prevertebral soft tissue swelling may occur in almost all patients undergone anterior cervical spine surgery as shown in our study. Moreover, the airway obstruction due to prevertebral soft tissue swelling is unpredictable.

In majority cases, we can detect patient respiratory discomfort only when he or she complain of their respiratory problems, therefore objective tool in clinical setting seems necessary in order to predict these problematic situations of patients such as dyspnea and airway obstruction. At the beginning this study, authors have expected that the method using patient's simple lateral cervical X-ray would be a good indicator for predicting clinical symptom due to airway obstruction of patients. But, we were not able to find any correlations of symptom with radiologic severity. One of the limitation of our study is only AP diameter were measured by lateral cervical radiographs and we believe that surface area of airway should be calculated as well in future study. But, laryngeal anatomical complexity may pose a problem because it would be difficult to measure crosssectional area of airway using only AP caliber of airway with simple lateral cervical radiographs. In case of the patient who showed severe airway narrowing in lateral film, the transverse diameter of airway was wide enough for aeration. He experience no respiratory emergency after surgery. As shown in Fig. 6, AP airway diameter was markedly shortened after surgery compared to preoperative film whereas transverse diameter showed no definite change before and after surgery. Transection view of around epiglottis gives us important clue why all patients who show severe airway narrowing

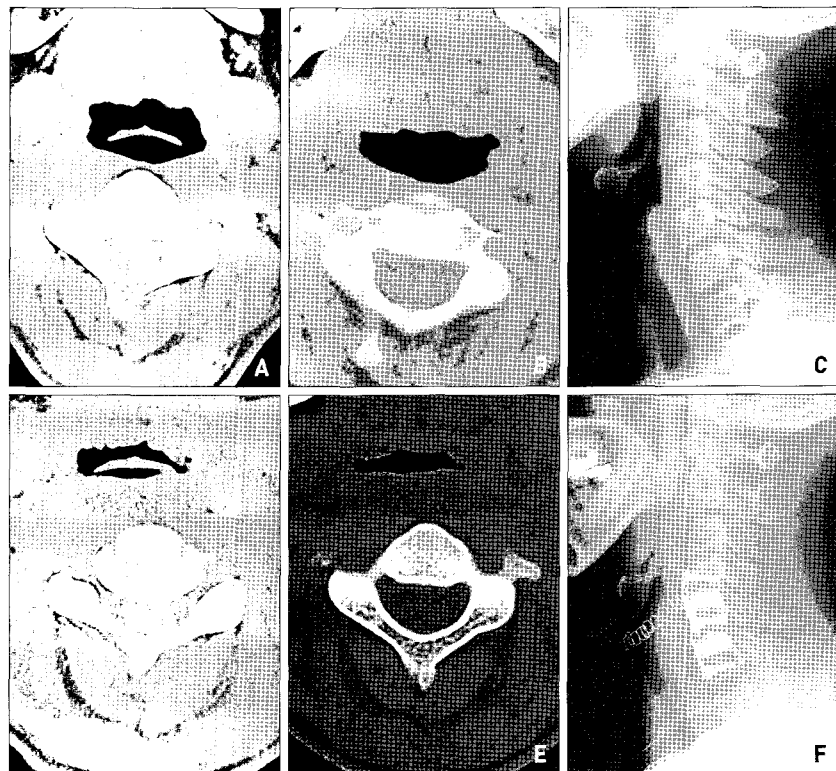


Fig. 6. A 52-year-old female who had severe airway narrowing and prevertebral soft tissue swelling but no definite respiratory complication. Compared with preoperative state, airway narrowing and prevertebral soft tissue swelling are maximum on 2nd operation day. CT scan revealed markedly narrowed AP airway diameter but transection diameter was not severely narrowed despite prevertebral soft tissue swelling. (A : Preoperative C-spine CT scan at above epiglottis, B : Preoperative C-spine CT scan at epiglottis level, C : Preoperative simple lateral film, D : 2nd operation day CT scan on above epiglottis, E : 2nd operation day simple X-ray film, F : 2nd operation day CT scan near epiglottis).

in lateral cervical X-ray film do not suffer from airway problem (Fig. 6). There could be enough space to ventilate no matter how AP airway diameter is narrow because several anatomic structures, like vallecula epiglottica, can serve as pathway for aeration (Fig. 7). The surface area of patients' airway was not significantly influenced by the shortened AP airway diameter.

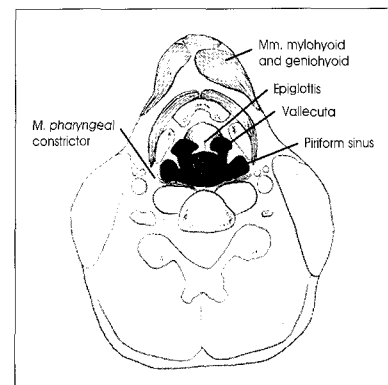


Fig. 7. Schematic view of airway nearby epiglottis. There could be enough space to ventilate no matter how AP airway diameter is narrowed because several anatomic structure like vallecula epiglottica can serve as pathway for aeration even when AP diameter become narrowing.

According to the article, we measured airway diameter and soft tissue thickness using simple lateral neck X-ray, therefore there can be some numerical errors. For example, it could have been magnified or reduced in length if lateral

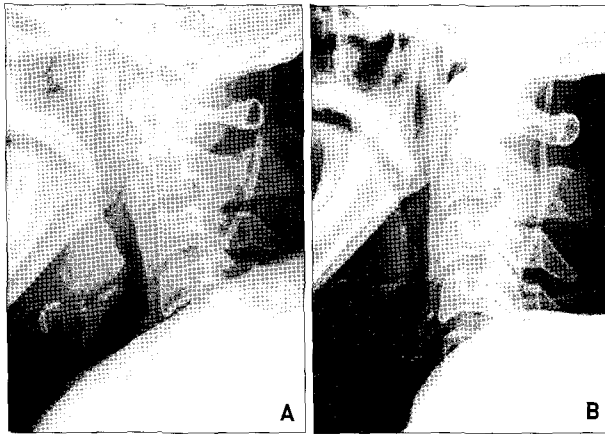


Fig. 8. The lateral cervical film of hydrocephalus patient who underwent ventriculoperitoneal shunt. He did not show severe airway narrowing and prevertebral soft tissue swelling at 2nd or 3rd day after surgery. This fact tells us simple mechanical airway irritation on surgery has no critical role on airway narrowing and prevertebral soft tissue swelling (A : Postoperative 2nd day, B : Postoperative 3rd day).

X-ray was taken from not exactly lateral direction but oblique direction^{6,7)}. Also, in some simple X-rays, because of poor image quality, we could not detect exact margin of airway and soft tissue.

With regards to possible physical or mechanical irritation of airway itself, like endotracheal intubation when general anesthetic procedure, that might have influence on prevertebral soft tissue swelling and airway narrowing, we compared data of patients who have undergone another operation with general anesthesia in our study cases (Fig. 8). As shown in Fig. 8, there was no definite airway narrowing and prevertebral soft tissue swelling at 2nd or 3rd postoperation days in a patient with ventriculo-peritoneal (V-P) shunt operation. The cause of airway narrowing and prevertebral soft tissue swelling were not from intra-airway mechanical irritation like intubation but rather mechanical traction of anterior cervical structure during surgery.

There have been several reports about airway obstruction after anterior cervical spinal surgery. Tew et al. reported that 2.3% patients needed reintubation after anterior cervical spinal surgery²²⁾. Sagi et al. investigated 311 patients who had undergone anterior cervical spinal surgery. Their incidence of airway obstruction was 6.1%¹⁸⁾. The risk factors included operation time, multilevel surgery, and blood loss more than 300 ml. Bookvar et al. also reported the risk factors as prolonged operation time, obesity, transfusion, reoperations, multilevel corpectomy and fusion, and asthma³⁾. Emery et al. reported airway obstruction after multilevel cervical corpectomy in 7 patients¹⁰⁾. The airway obstruction was due to edema and their risk factors were smoking and asthma. Martin et al. demonstrated that prevertebral soft tissue swelling may contribute to dysphagia, dysphonia, and

overall feeling of neck fullness following anterior cervical spine surgery^{13,24)}. Hematoma formation is one of the factor to induce prevertebral soft tissue swelling and airway narrowing as was reported by several authors that can be prevented by careful hemostasis and the use of suction drain^{16,22)}. In our study, the main cause of airway narrowing was considered to be prevertebral soft tissue edema, because a suction drain was used routinely and hematoma formation were ruled out.

There have been few reports concerning the natural history of the prevertebral soft tissue swelling after anterior cervical spine surgery. In our study, the prevertebral soft tissue swelling and airway narrowing were peak on the 2nd and 3rd day after surgery. Therefore, it is important that intensive patients monitoring and observation for 2 to 3 days after anterior cervical spinal surgery seem mandatory. But, there were no statistical correlations between respiratory insufficiency and airway narrowing and prevertebral soft tissue swelling. It is one of the reason that respiratory difficulty is subjective symptom and there's no quantified method to check the degree of respiratory difficulty at bedside. All of respiratory complicated patients showed normal oxygen saturation on pulse oxymeter monitoring. Thus, more study should be followed to evaluate the symptomatic characteristics of the patients and their radiologic correlations.

CONCLUSION

The pattern of airway narrowing and prevertebral soft tissue swelling within postoperative 2 weeks showed maximum at 2nd operation day and diminished within 7 days. The degree of airway narrowing has no clinical correlation with patient's symptom but it may serve as a meaningful indicator for vulnerable period of postoperative patient's care.

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