

Acquired Laryngeal Deviation Associated with Cervical Spine Disease in Erosive Polyarticular Arthritis

Use of the Fiberoptic Bronchoscope in Rheumatoid Disease

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Cervical spine disease in patients with erosive polyarticular arthritis often presents difficulties in endotracheal intubation at the time of surgery. After extensive experience with the use of the fiberoptic bronchoscope in such situations, the authors have identified a previously unrecognized and unanticipated tri-plane deviation in which the larynx is displaced caudally, deviated to the left, rotated to the right, and anteriorly angulated.

A review of 710 consecutive fiberoptic intubations identified 15 arthritis patients with laryngeal deviation. Documentation was available in seven patients showing that the larynx was initially in a normal position, but was progressively displaced as the cervical spine disease worsened. Vertical penetration of the dens was the most significant underlying pattern of cervical spine disease. Computerized tomography with multiplanar reconstruction elucidated two patterns of deformity but was not necessary to detect the laryngeal deviation. One cause of the deviation was a scoliotic deformity of the trachea and larynx secondary to shortening of the neck resulting from the vertical penetration. The second mechanism was a rotational deformity of the cervical spine occurring from asymmetric bony erosions.

Knowledge of this deformity permits it to be easily predicted preoperatively so that appropriate management can be planned. (Key words: Airway; anatomy. Anatomy: airway. Complications: arthritis. Intubation, endotracheal: technique.)

CERVICAL SPINE DISEASE in patients with erosive polyarticular arthritis often presents difficulties in endotracheal intubation at the time of surgery. Use of the flexible fiberoptic bronchoscope for such problems is a well-described technique of proven value.^{1,2}

The most common indications for fiberoptic intubation in the arthritis patients are: 1) an unstable cervical spine on flexion and extension; 2) limited mobility of the cervical spine; and, 3) impaired motion of the temporomandibular joints with or without associated micrognathia.

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Depending upon the particular study and the diagnostic criteria used, the involvement of the cervical spine may be found in from 6.4% to 90% of patients with rheumatoid arthritis.³⁻⁶ Lateral flexion-extension x-rays of the cervical spine are a routine preoperative study performed on the Arthritis Service patients at Rancho Los Amigos Hospital. Any patient with radiographic evidence of cervical spine instability becomes a candidate for fiberoptic intubation at the time of surgery. In addition, all patients are assessed preoperatively by the anesthesiologist for clinical mobility of the cervical spine and ability to open the mouth widely. Individuals with impaired range of motion also are scheduled for fiberoptic intubation.

Because of this policy, the experience with fiberoptic intubation in arthritis patients at Rancho Los Amigos Hospital has been extensive. Certain arthritis patients were noted to have an unanticipated but consistent pattern of deviation of the larynx. The current study was undertaken to investigate further this laryngeal deviation. The purpose of this report is therefore threefold: 1) to describe the abnormal position of the larynx; 2) to illustrate that the laryngeal deviation is an acquired abnormality; and 3) to define the etiologic mechanisms of the laryngeal deviation.

Materials and Methods

This study consisted of two portions. The first segment involved a retrospective review of the records of 710 consecutive fiberoptic intubations performed in the past 12 years. The first 400 intubations were performed by the same anesthesiologist (C.M.S.). There were 17 patients identified with deviation of the larynx. Two patients were eliminated from the study because local pathology involving the larynx was believed to have caused the deviation. There remained 15 patients with unexplained deviation of the larynx.

Hospital charts and anesthesia records then were examined. The diagnosis, surgical history, and pertinent demographic data were recorded. It was theorized that the laryngeal deviation was related to cervical spine abnormalities resulting from the arthritis. Therefore, the lateral cervical spine flexion-extension x-rays were examined in each patient, and measurements were made

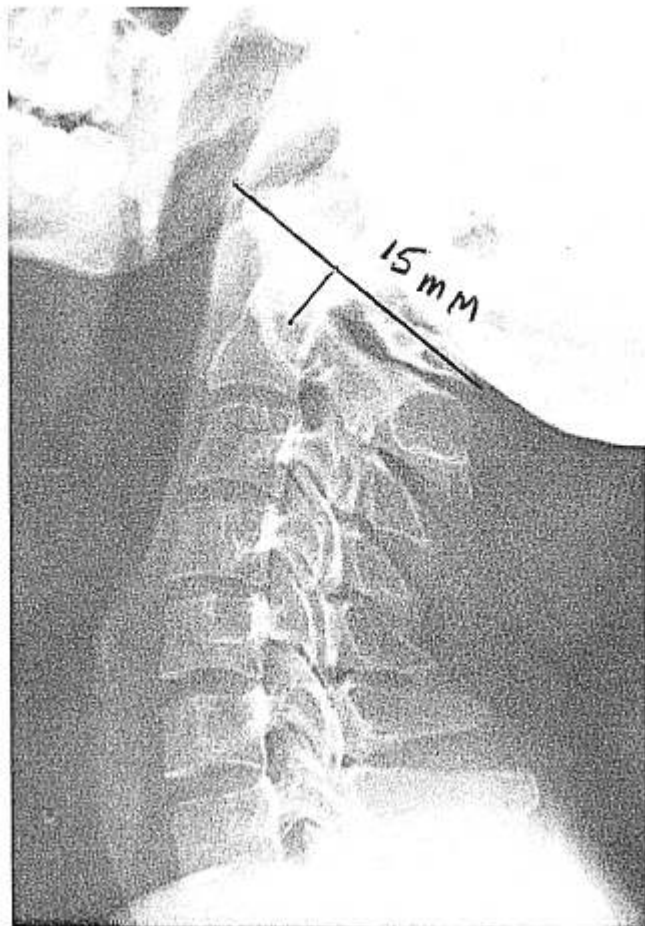


FIG. 1A. Lateral view of a normal cervical spine. To determine the extent of superior migration of the odontoid, the distance between the coronal axis of C1 and the center of the pedicle of C2 is measured. The normal distance is never less than 13 mm.

of the atlantoaxial motion and subaxial alignment on lateral flexion-extension views. Superior migration of the odontoid was measured on standard lateral views using the perpendicular distance between the arch of the atlas and the center of the pedicle of the axis as described by Ranawat *et al.*⁷ (fig. 1). Any additional abnormalities such as fractures or rotational malalignment also were noted. Computerized tomography with multiplanar reconstruction was available in four patients and further assessed the nature of the cervical spine involvement relative to the position of the trachea and larynx.

Based on the information obtained from the retrospective review, a prospective study was designed to determine whether clinical examination and routine x-rays were sufficient to predict the presence of laryngeal deviation. Forty-nine consecutive preoperative patients on the Arthritis Service were screened during a 3-month

interval. All patients had lateral flexion-extension x-rays of the cervical spine which were evaluated for the presence of vertical migration of the dens. No patient had computerized tomography of the spine. Each patient also was examined by the authors and the alignment of the larynx with the sternal notch was noted.

Results

As viewed with the aid of the fiberoptic bronchoscope the pattern of laryngeal deviation in the arthritic patient is constant. The deformity occurs in three planes reminiscent of scoliosis. The larynx is displaced anteriorly and laterally to the left. The vocal cords are rotated in a clockwise direction. The third component of the deformity is a forward tilt with the anterior aspect of the larynx positioned more caudally than the posterior portion (fig. 2).

All 15 patients who were included in the retrospective study were noted to have erosive forms of systemic

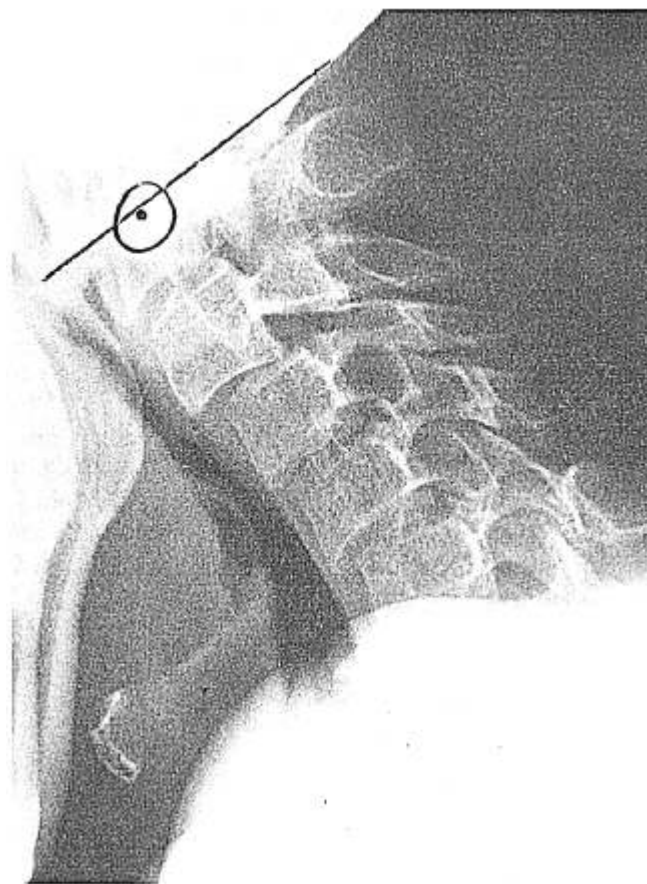


FIG. 1B. Lateral view of cervical spine showing marked superior migration of the odontoid process. Radiographic detail is obscured by the overlapping of bony structures which results from the altered anatomy.

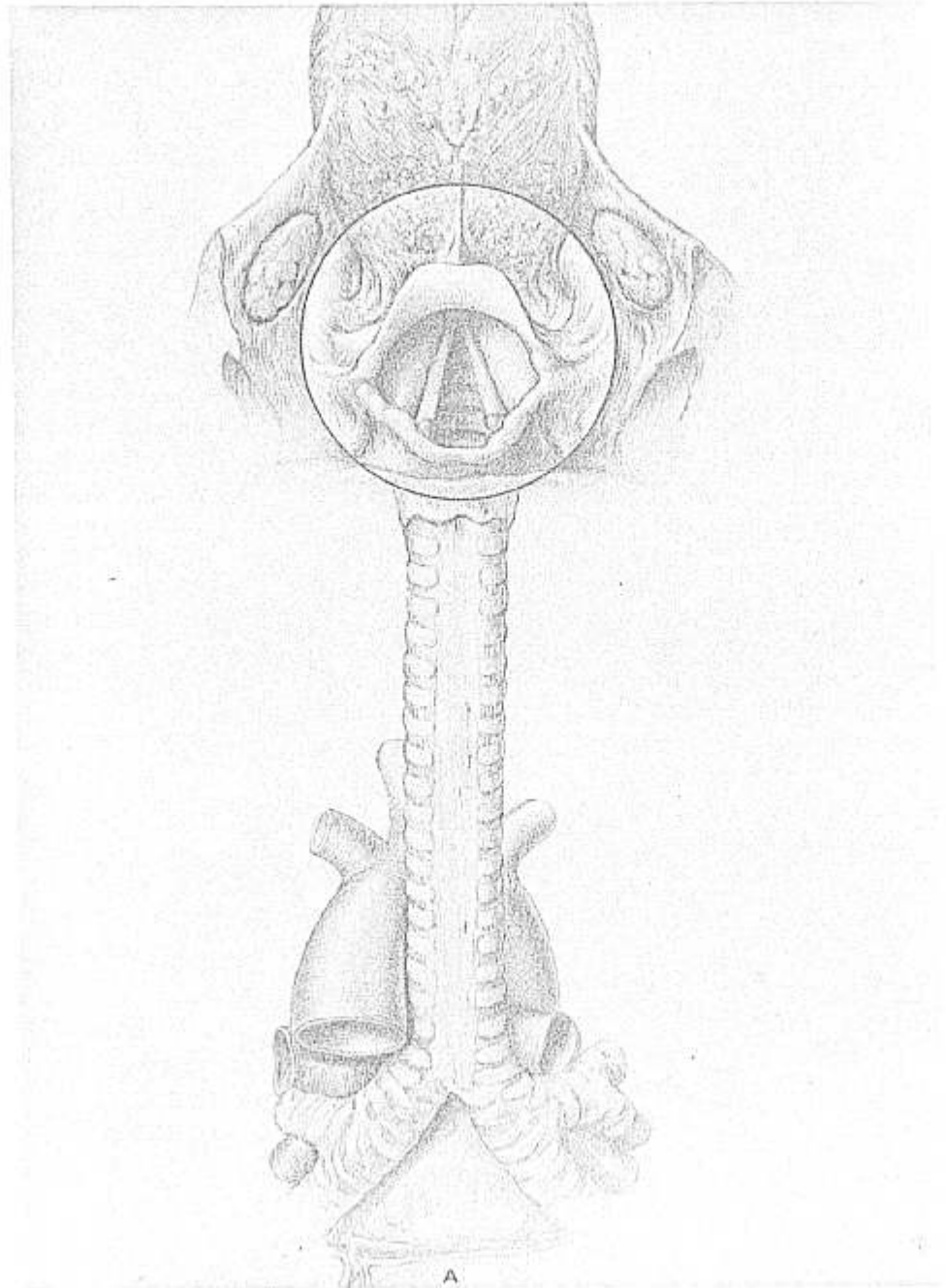


FIG. 2A. Normal position of the trachea and larynx. Insert area represents view through the fiberoptic bronchoscope.

arthritis (table 1). The sex distribution was equal with eight patients being male and seven patients being female. The age of the patients when the laryngeal deviation was first noted ranged from 14 to 64 years, with a mean of 43.3 years.

All patients had severe involvement of their peripheral joints as well as advanced cervical spine disease. Although they showed all patterns of cervical spine involvement by the arthritis process, *i.e.* atlantoaxial instability, subaxial subluxations, and proximal migration

of the dens, the proximal migration of the dens was statistically the most significant finding. Severe proximal displacement of the odontoid process was found in 13 of the 15 patients (86.7%). The remaining two patients had borderline measurements of early displacement.

Documentation by repeated direct laryngoscopy over a period of years was available in seven of the 15 patients demonstrating that the laryngeal deviation was an acquired abnormality which progressed as the amount of vertical penetration of the odontoid increased. Review

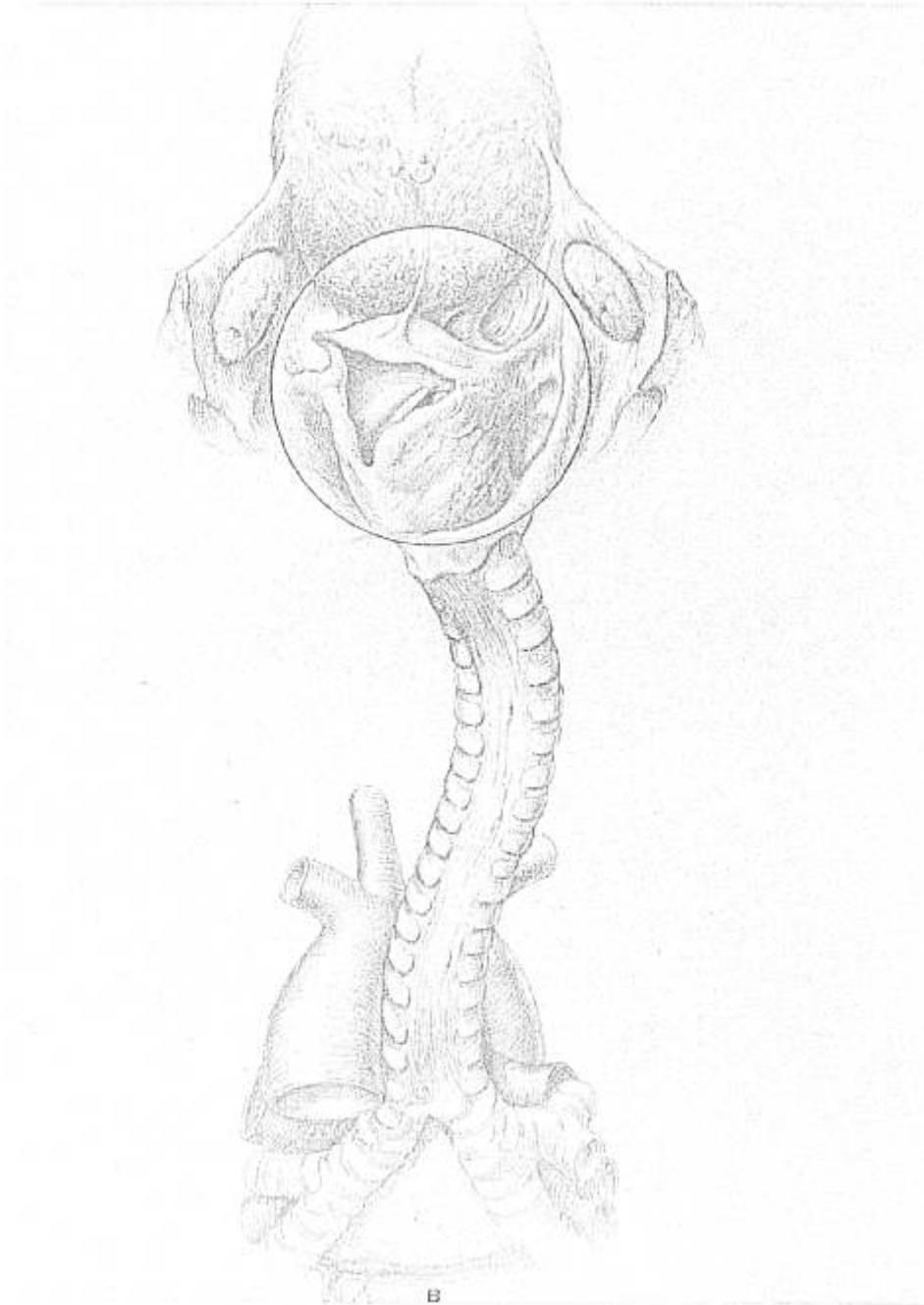


FIG. 2B. Deviated position of the trachea and larynx associated with severe arthritis of the cervical spine. Insert area represents view through the fiberoptic bronchoscope.

of the hospital and anesthesia records revealed that the larynx initially was situated in a normal position, first moved anteriorly, and then assumed its fully rotated and deviated position. This movement of the larynx correlated with the progressive involvement of the cervical spine by the arthritic process.

Evaluation of computerized tomography with multiplanar reconstruction in four patients documented the deviated position of the larynx relative to the spine. It also helped to elucidate the relationship of the vertical

penetration of the dens to the laryngeal deviation. Detailed analysis of serial sections in multiple projections were required to reconstruct the relationship of the larynx with the cervical spine (fig. 3).

All four patients were seen to have a rotational malalignment between the spine and the larynx. The larynx also was displaced caudally (fig. 4). In three patients, rotational abnormalities of the cervical spine were seen resulting from asymmetric erosions of the vertebral bodies. This led to a scoliotic deformity of the spine not

evident on plain films. The remaining patient had a scoliotic deformity of the trachea and larynx with the cervical spine remaining relatively straight.

Clinical examination by the authors of five patients in the retrospective group revealed the patients each to have the appearance of a short neck. During visual inspection no rotational malalignment of the head was apparent. When the position of the larynx was palpated in relation to the sternal notch, however, the rotational deformity was clinically detectable in three patients (fig. 5). A laterally tilted head position was seen in two patients.

In the prospective portion of this study, 49 consecutive preoperative patients on the Arthritis Service were screened. Clinical alignment of the larynx relative to the sternal notch and the presence of proximal migration of the dens on lateral roentgenograms of the cervical spine were the only parameters considered.

There were three patients identified who had proximal migration of the dens seen on routine lateral x-rays of the cervical spine. These individuals also were noted to have rotational malalignment of the larynx to the sternal notch. The remaining 46 patients did not show either abnormality.

At the time of surgery the larynx was examined vi-

TABLE 1. Patients with Laryngeal Deviation

Patient	Age	Sex	Diagnosis	Perpendicular Distance* (Normal \geq 13 mm)
1	14	Male	JRA	10 mm
2	52	Female	RA	13 mm
3	31	Male	AS	13 mm
4	62	Male	AS	0 mm
5	61	Female	RA	0 mm
6	41	Female	RA	10 mm
7	33	Male	PA	0 mm
8	43	Female	RA	2 mm
9	17	Male	JRA	7 mm
10	34	Male	RA	0 mm
11	65	Male	RA	4 mm
12	31	Female	JRA	3 mm
13	56	Male	RA	8 mm
14	62	Female	RA	8 mm
15	48	Female	PA	10 mm

JRA = juvenile rheumatoid arthritis; RA = rheumatoid arthritis; AS = ankylosing spondylitis; and PA = psoriatic arthritis.

* Perpendicular Distance = distance, measured in mm on standard lateral x-ray of the cervical spine, between the arch of C1 and the pedicle of C2. A measurement of less than 13 mm indicates superior migration of the odontoid.

sually and its position noted. All three patients with proximal migration of the odontoid and clinical malalignment of the larynx and sternal notch demonstrated

FIG. 3. Computerized tomography of the cervical spine. The planes of the coronal and sagittal reconstructed images are located by the axial cross section in the upper left corner.



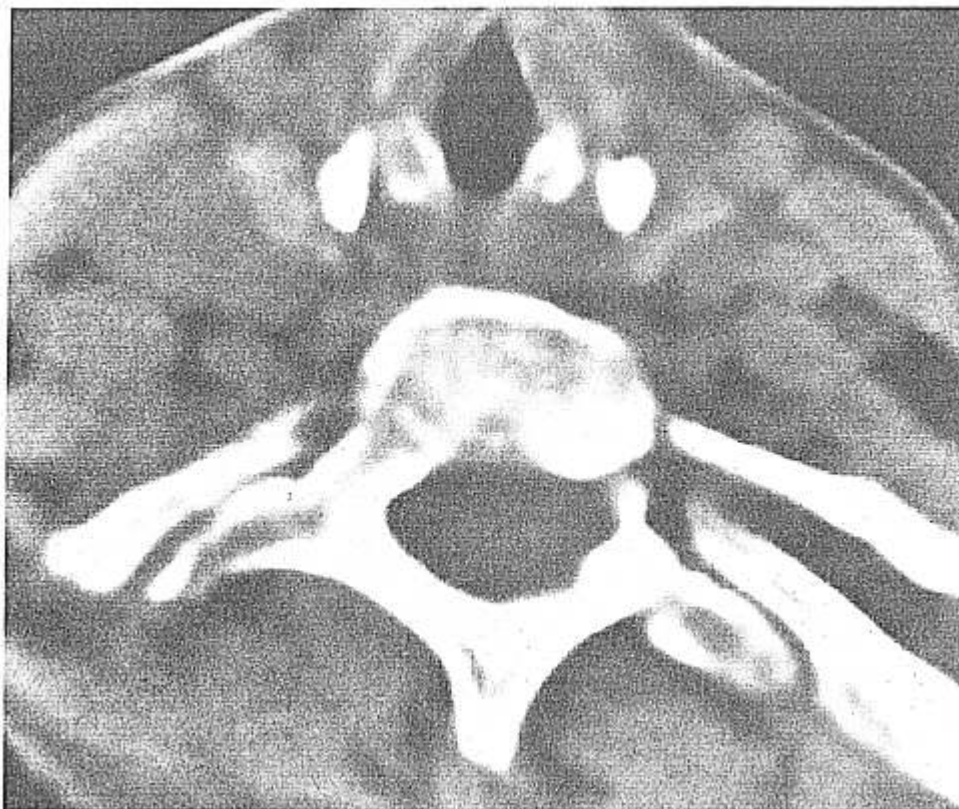


FIG. 4. Computerized tomographic scan at T1-T2 level (note the ribs) showing larynx displaced caudally and rotated in relation to spine.

the tri-plane laryngeal deviation. The other 46 patients had no apparent laryngeal abnormalities. This represents an incidence of 6.1% of this deformity in the patient population at our institution.

Discussion

Depending upon the particular study and diagnostic criteria used, involvement of the cervical spine may be found in from 6.4% to 90% of patients with rheumatoid arthritis.³⁻⁶ Involvement of the cervical spine in rheumatoid arthritis is classically divided into three categories.⁴ These deformities may occur singly or in any combination. The most common form of cervical spine involvement is atlantoaxial instability resulting from erosion of the transverse and alar ligaments. These ligaments normally function to maintain the odontoid process of the axis within the anterior third of the ring of the atlas where the two bones articulate with one another (fig. 6). Disruption of the transverse and alar ligaments results in excessive motion between C1 and C2 and possible impingement of the spinal cord. Atlantoaxial instability is therefore an indication for fiberoptic intubation because forward flexion of the head could result in pressure on the spinal cord by the posteriorly subluxing dens.⁸

The second most common form of arthritic spine disease is the broad category of subaxial instability. This can be manifested by subluxation occurring between two or more cervical vertebrae below the level of C2. When the degree of subluxation is severe or its occurrence is sudden, pressure again can be exerted on the spinal cord. This pressure may be sufficient to cause permanent and complete quadriplegia.

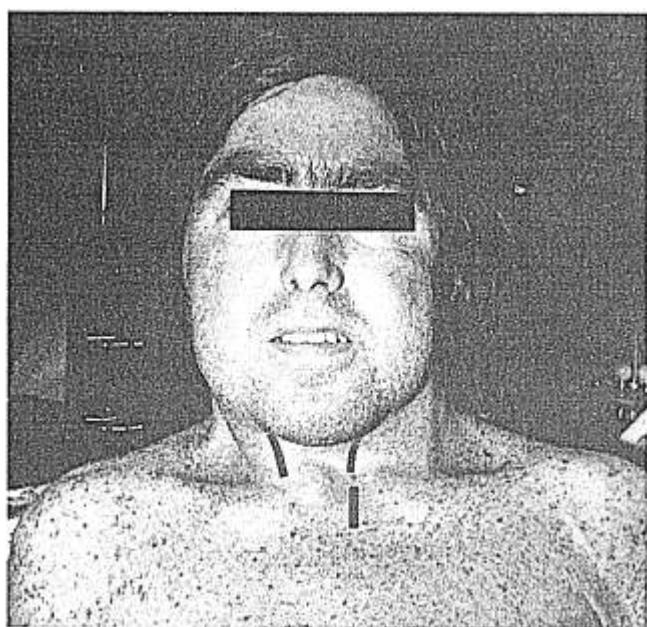


FIG. 5. Photograph of arthritis patient with laryngeal deviation detected clinically. The superior lines mark the larynx. The inferior line is situated in the center of the sternal notch.

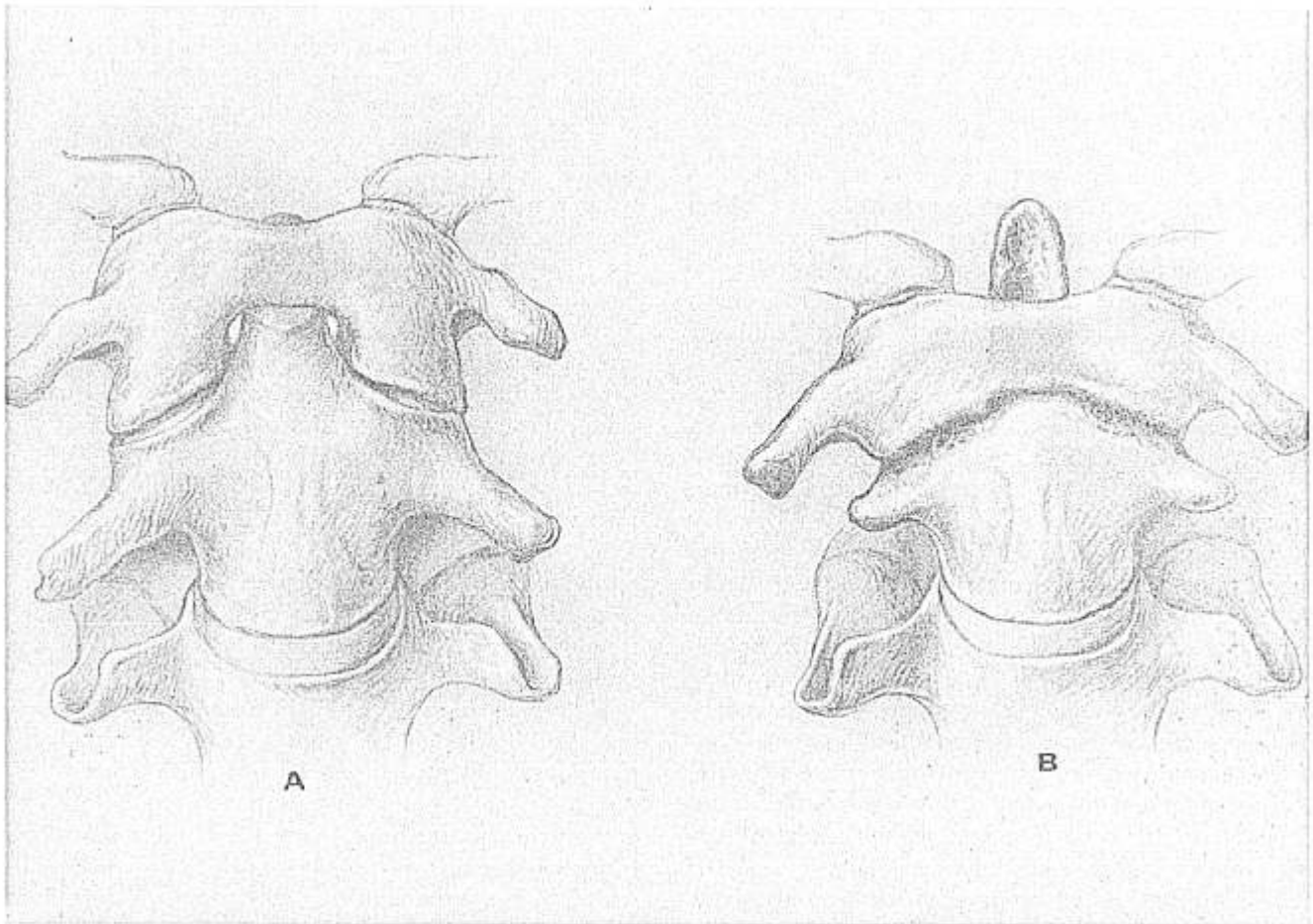


FIG. 6. (A, left). Anterior view of the normal relationship between the C1 and C2 vertebrae. (6B, right). Anterior view of C1 and C2 with bony erosions resulting in superior migration of the odontoid process.

The least common pattern of cervical spine deformity is superior migration of the odontoid process resulting from severe degrees of bone erosion (figs. 3, 4, and 5). Pellicci *et al.*,⁴ in their prospective study of cervical spine involvement in rheumatoid arthritis, showed only four of 106 patients (3.8%) with superior migration of the odontoid occurring either alone or in combination with another pattern of instability at the outset of their study period. After five years the number had increased to 10 of 106 patients (9.4%) with vertical penetration of the dens. Sherk⁹ reported five of 65 patients (7.7%) in his series with superior migration.

The patient population at our institution tends to have more advanced disease than those individuals seen in the private sector. An audit was performed of the 133 adult onset rheumatoid arthritis patients admitted to the Arthritis Service during 1980. The mean age was 58.2 years. There were 106 female and 27 male patients. Vertical penetration of the dens was noted in 20 patients (15%) (table 2).

The previous figures should be contrasted with the fact that 13 of the 15 patients (86.7%) in the retro-

spective series with laryngeal deviation showed definite vertical penetration and the remaining two patients had borderline measurements. Even accounting for the increased incidence of vertical penetration of the odontoid process in our patient population, an 86.7% incidence of this deformity in the retrospective group of patients with laryngeal deviation represents a statistically significant ($P = 0.005$) increase from the expected

TABLE 2. Cervical Spine Involvement of All Adult Onset Rheumatoid Arthritis Patients Admitted to Rancho Los Amigos Hospital during 1980

Level	Patients	Percentage
C1-C2		
Atlanto-axial subluxation	57	43%
Vertical penetration of dens	20	15%
C2-C3	4	17%
C2-C5	20	15%
C5-C6	8	6%
C6-C7	1	1%
C7-T1	4	3%
Multiple levels	27	20%

incidence. Vertical dislocation of the dens therefore should alert one to the possibility of encountering a triplane deviation of the larynx which could make endotracheal intubation difficult, if not impossible, with routine methods.

The measurement of the perpendicular distance between the arch of C1 and the pedicle of C2 was chosen for use in this study to document superior migration of the odontoid because lateral roentgenograms of the cervical spine often did not include enough of the hard palate to allow measurement using other techniques such as those described by Chamberlin and McGregor.^{10,11} In normal men the perpendicular distance averages 17 mm with a standard deviation of 2 mm. In women it averages 15 mm with a standard deviation of 2 mm. The interval should never measure less than 13 mm.⁷

Two distinct patterns relating the cervical spine and the tracheobronchial tree emerged during the study. In the first, the predominant abnormality is a rotational deformity of the spine with the trachea and larynx remaining relatively straight. The rotational abnormalities of the cervical spine occur at many levels secondary to asymmetric erosions of the vertebral bodies.

The second pattern is the reversal of the first; the cervical spine remains straight while the larynx and trachea become deviated. The semi-rigid trachea and larynx assume a scoliotic deformity secondary to the shortening of the neck which occurs as the dens progressively penetrates the foramen magnum. The trachea and larynx rotate in a constant direction because of the teth-

ering effect of the arch of the aorta as it passes posteriorly over the left main stem bronchus (fig. 2).

The problems encountered in establishing and maintaining an adequate airway in the arthritis patient may be numerous. Inability to position the head and neck adequately, cervical spine instability, and decreased temporomandibular joint motion are all indications for fiberoptic intubation. The limited field of vision through the fiberoptic bronchoscope makes knowledge of any deviated position of larynx most important for successful intubation. The relative shortening of the neck secondary to vertical migration of the dens causes the soft tissues of the pharynx to become redundant, further compromising the airway and obscuring vision of the larynx through the fiberoptic bronchoscope (fig. 7). The technique is therefore more difficult in those patients with vertical penetration. Lee and Andree¹² reported a case of airway obstruction and difficult endotracheal intubation in a patient with degenerative cervical spondylosis. The cause of the laryngeal deviation was different in their patient, but the resultant problem was similar.

Knowledge of the direction of the laryngeal deviation may not be sufficient to compensate for the redundant pharyngeal soft tissues and the tortuous course necessary to approach the larynx using routine methods of endotracheal intubation. Using the flexible fiberoptic bronchoscope the view of the vocal cords is often obscured by the prominent right arytenoid which is tilted upward into the field of vision. It is often necessary to maneuver the scope first to the left then over the right

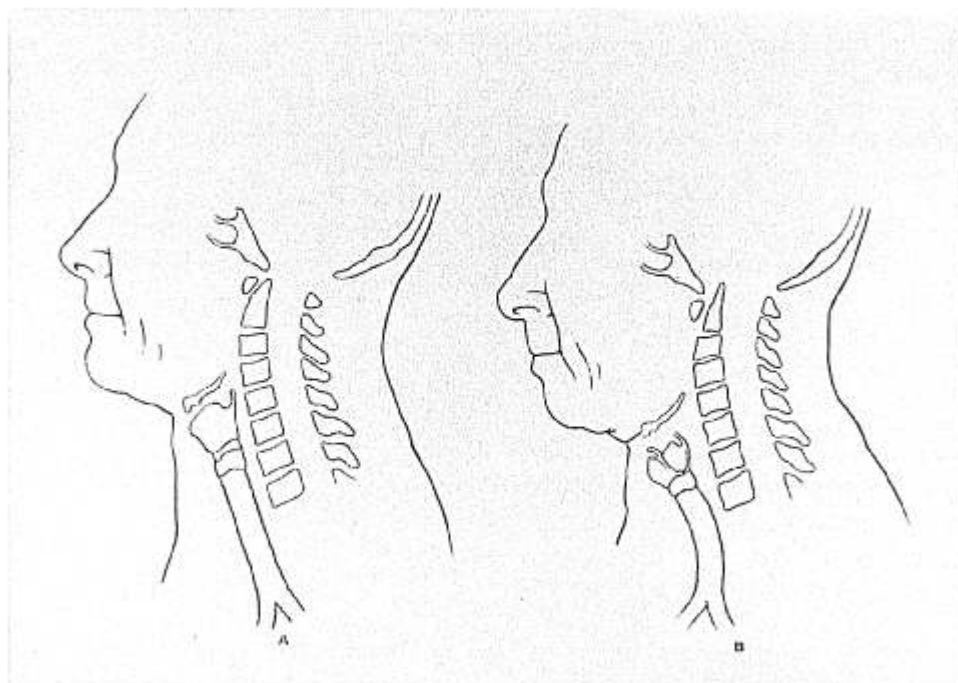


FIG. 7. (A, left). Normal lateral view of the relationship between the laryngotracheal tree and the cervical spine. (7B, right) Lateral view showing superior migration of the odontoid process in the arthritic patient with resulting scoliotic deformity of the trachea and larynx.

arytenoid and finally downward and to the right through the vocal cords.

Rotational deformities rarely are appreciated on routine roentgenograms of the cervical spine because of distortion or lack of the usual guides to interpretation. Bony landmarks are eroded and the degree of osteoporosis is severe in this population, further complicating the picture. The marked degree of superior migration of the dens results in overlapping of the skull and proximal cervical spine on the x-ray, again obscuring the detail (fig. 1B). Computerized tomography was obtained only when needed by the orthopedic surgeon and rheumatologist to evaluate the cervical spine deformities in greater detail.

Computerized tomography is not necessary to predict the presence of deviated larynx. The prospective portion of this study indicates that knowledge of the laryngeal deviation allows it to be predicted easily and reliably preoperatively with routine examination methods. The arthritis patient with severe involvement of the peripheral joints should be highly suspect as these patients are more likely to have severe cervical spine disease as well.³⁻⁵ A single lateral roentgenogram of the cervical spine is all that is required to show superior migration of the dens. This finding alone should alert one to prepare for a deviated larynx and a difficult intubation. Clinically, the rotational deviation of the larynx can often be detected by palpating the position of the larynx in relation to the sternal notch.

In summary, a previously unappreciated and unanticipated tri-plane deviation of the larynx was identified and described in patients with erosive polyarticular arthritis involving the cervical spine. The laryngeal deviation was shown to be an acquired deformity and two

etiologic mechanisms were discussed. The technique of intubation using a fiberoptic bronchoscope was reviewed. Guidelines were described to predict the deviation of the larynx preoperatively so that appropriate planning may be undertaken and a possible disaster averted.

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