Cervical Spine Radiographs in Patients With Rheumatoid Arthritis Undergoing Anesthesia

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Background: There is no consensus on the role of preoperative cervical spine radiographs to screen for instability in patients with rheumatoid arthritis (RA).

Objectives: This study aimed to evaluate the preoperative use of cervical spine radiographs in patients with RA undergoing preoperative anesthesia assessment and to determine whether preoperative radiographic findings influenced anesthesia delivery techniques.

Methods: We reviewed all medical records of RA patients who underwent surgical procedures requiring general anesthesia with airway intubation or monitored anesthesia care without airway intubation. We examined cervical spine radiographs obtained up to 2 years before surgery and determined airway management techniques used during surgery.

Results: Overall, 215 patients with RA underwent 217 individual surgeries requiring anesthesia; of these, 176 (82%) underwent general anesthesia with airway management with direct laryngoscopy in 83%, fiber-optic intubation in 10%, and laryngeal mask in 7%. Ninety-two (52%) of the patients receiving airway management had radiographs available for cervical spine evaluation; of these, only 7 (8%) had complete radiographic examinations with which to evaluate possible atlantoaxial subluxation. Eighteen (20%) of the 92 patients receiving airway management had radiographic evidence of cervical spine abnormality. Multiple regression models were conducted to evaluate the association of patient demographics and airway management technique used and showed that the use of fiber-optic intubation or laryngeal mask was not influenced by radiographic results. A difficult oropharyngeal class/glottic visualization grade (3 or 4) as determined by the anesthesiologist was the only statistically significant predictor of fiber-optic intubation or laryngeal mask use.

Conclusions: Cervical spine abnormalities were frequently noted in patients who underwent general surgery but did not influence the choice of airway management. Future prospective studies evaluating the utility of cervical spine radiographs in patients with RA and practice guidelines are needed to ensure appropriate and cost-effective perioperative cervical evaluation and management of patients with RA.

Key Words: cervical spine, rheumatoid arthritis, surgery, anesthesia management, adequacy of radiographs

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Early cervical spine involvement is relatively common in rheumatoid arthritis (RA). Between 17% and 86% of RA patients have evidence of cervical spine disease within 5 years after initial diagnosis,[1–3] with synovitis and pannus formation that can weaken the transverse, alar, and apical ligaments. The continuous strain of these ligaments by stretching or rupture can cause atlantoaxial subluxation (AAS) and subaxial subluxation (SAS),[4] with instability that can compress the spinal cord, resulting in vascular or neurological complications and ultimately paralysis or death.

Surgical procedures among RA patients are common. More than 25% of RA patients undergo orthopedic surgery within 10 to 20 years after diagnosis.[5–7] In addition, patients also undergo general surgery and other procedures requiring anesthesia, in relation to their comorbidities. Patients with instability of the cervical spine may be at increased risk of spinal cord injury from alterations of head and neck position during airway management and/or positioning (flexion/extension) for surgery.[8–11] Intubation techniques that minimize extremes of positioning are used to avoid potential complications that may result from an unstable cervical spine.[12] The most common intubation technique employed in the presence of an unstable cervical spine is called "awake fiber-optic intubation." In this technique, the airway is anesthetized using topical anesthesia. While keeping the patient's spine in an anatomically neutral position, a fiber-optic bronchoscope is used to place the endotracheal tube in the trachea. The goal is intubation with minimal to no neck motion. Once the placement is secured, a motor examination on the patient is performed to rule out any neurological damage. Then induction toward a full general anesthetic is completed and surgery is performed.

Radiological examination may play a role in identifying patients at risk for neurological complications. Abnormalities on the radiograph can help anesthesiologists determine the appropriate intubation technique. If no instability is observed, then the anesthesiologist may elect to use conventional intubation techniques. If instability is observed, depending on the location and severity of the instability, and other conditions, the anesthesiologist may decide to use airway techniques that result in lesser cervical spine motion than conventional direct laryngoscopy. Plain radiography is the most common screening modality available for cervical spine instability. Magnetic resonance imaging and computed axial tomography can also be diagnostic but are more costly.

The objective of this study was to determine the use of preoperative cervical radiographs in patients with RA undergoing general surgery or other procedures requiring general anesthesia at the largest Comprehensive Cancer Center (National Cancer Institute denomination) in the United States (The University of Texas MD Anderson Cancer Center). We determined the frequency and type of radiographs available, radiographic findings, airway management, and postoperative course. Most of the previous studies have been conducted in patients with RA undergoing orthopedic surgery. To our knowledge, this is the first large study of patients with RA undergoing nonorthopedic surgery and the first study on the influence of radiographic utilization and findings on intubation technique.

PATIENTS AND METHODS

We used MD Anderson's clinical information retrieval system to identify RA patients, who underwent preoperative anesthesia assessment between November 2002 and November 2006, and reviewed their medical records. For our initial screening, we used the diagnosis of RA as a comorbidity in the electronic anesthesia databases. These databases are comprehensive with respect to

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comorbidities, which are reviewed by the anesthesiologist at the time of the preoperative assessment. We only included patients with a diagnosis of RA as reported by a rheumatologist or an internist in the medical chart, with documentation of ongoing or prior treatment for RA (traditional disease-modifying antirheumatic drugs or biologic agents), and at least 18 year of age. The main purpose of our study was to evaluate those patients undergoing surgeries or other procedures under general anesthesia with airway management, and we selected the first procedure during the study period for each patient. In addition, we also evaluated patients undergoing monitored anesthesia care without intubation (i.e., sedation) to determine practice patterns since monitored anesthesia interventions can be switched to airway management if the procedure becomes lengthy or complex. Two independent reviewers (M.L.O. and T.A.) extracted patients' characteristics, clinical information, and surgery and procedure data from the patients' medical records.

We searched for cervical spine radiographs obtained within 2 years before the intervention from the patients' electronic records and reviewed them to determine whether they were adequate to evaluate cervical spine instability. The adequacy of the cervical spine radiographs was classified using a modified version of the guidelines established by Kwek et al.: (1) complete (lateral views of the neck in flexion and extension, a frontal view of the entire cervical spine, and a frontal, open-mouth odontoid view), (2) adequate (lateral views of the neck in flexion and extension and a frontal view of the entire cervical spine), (3) semiadequate (lateral views of the neck in flexion and a frontal view of the entire cervical spine), (4) inadequate (lateral views of the neck in the neutral position and a frontal view of the entire cervical spine), and (5) none (no radiographs).[13] We examined the radiologists' reports and also evaluated each radiograph individually to confirm findings. Atlantoaxial subluxation was identified on radiographs by measuring the interval from the midposterior margin of the anterior ring of the C1 vertebra to the anterior surface of the odontoid process; an anterior atlantodental interval equal or greater than 3.0 mm was considered abnormal.[14,15] The posterior atlantodental interval was also measured; an interval greater than 14 mm was considered abnormal. Subaxial subluxation was defined as a subluxation of one of the vertebral body on another greater than 3.0 mm.[3,16] Surgical fusions and mild displacements (1–3 mm) were also noted.

We collected oropharyngeal class and glottic visualization grade from the preoperative assessment and the anesthesia records for each patient to determine whether difficulty in intubation was associated with anesthesia delivery. To categorize oropharyngeal class, we used the modified Mallampati classification, which describes the visualization of the soft palate when the mouth is fully open[17,18] to predict a difficult intubation. Class I is defined as visualization of the soft palate, fauces, uvula, and anterior and posterior pillars; class II, visualization of the soft palate, fauces, and uvula; class III, visualization of the soft palate and the base of the uvula; and class IV, airway visualization, the soft palate is not visible at all. To categorize glottic visualization grade, we used Cormack and Lehane's[19] guidelines, which define 4 grades of glottis visualization using a direct laryngoscope. Grade 1 indicates complete glottis visualization, grade 2 implicates only posterior portion of glottis can be seen, grade 3 suggests that only epiglottis may be seen, and grade 4 evidences no glottis visualization.

For airway management, 1 of 3 techniques was used: a) general anesthesia with laryngeal mask airway, b) general anesthesia with direct laryngoscopy and endotracheal intubation, or c) general anesthesia with fiber-optic intubation. The latter is considered the safest method in known or suspected cases of difficult intubation or in the presence of cervical spine instability. The technique's advantage is that it permits the endotracheal tube to be introduced into the trachea with direct visualization of the larynx but without the manipulation of cervical spine.

All patient records, anesthesia, and postanesthesia care unit reports were reviewed by an anesthesiologist (T.A.) for neurological and vascular complications. We thoroughly examined patient histories, searching in particular for transient or persistent central neurological deficits (i.e., brainstem ischemia with vertigo, dizziness, acute deficits in motor function or sensibility, dysarthria, dysphagia, or ocular movement disorders) and peripheral neurologic symptoms (i.e., arm claudication, numbness, or weakness).

Statistical Analysis

Two-sample *t* tests were conducted to compare continuous variables. Both chi-square and Fisher exact tests, when appropriate, were used to assess the relationship between the categorical variables and patient subgroups. Comparisons were made for a) patients with radiographs versus patients with no radiographs available, b) patients with abnormalities detected versus patients without abnormalities, and c) patients undergoing surgeries versus procedures. We defined procedures as events where incisions are not made (e.g., colonoscopies, endoscopies). Two-tailed $P < 0.05$ was considered statistically significant. All statistical analyses were performed using Stata 11 statistical software (version 10; StataCorp, College Station, Tex). Multiple regression models were estimated to evaluate the association among patient demographics (e.g., age, sex, and disease duration), radiograph use and abnormalities, and airway classification (oropharyngeal class and glottic visualization grade) with anesthesia delivery techniques. Disease duration could not be estimated with precision, so it was categorized for the analysis as follows: 2 years, 2 to 5 years, and more than 5 years, as these intervals could be estimated for most patients.

The study was approved by The University of Texas MD Anderson Cancer Center Institutional Review Board.

RESULTS

We identified 215 RA patients (67% female) who underwent 217 surgeries and 94 other nonsurgical procedures with airway management or monitored anesthesia care without airway management; 66 patients underwent more than 1 surgery or procedure. Sixty different anesthesiologists were identified providing anesthesia care for 1 or more procedures. Of the 215 patients, 176 underwent a procedure with airway management. For those undergoing more than 1 intervention, only the first intervention was included in the analysis. Of these, 92 (52%) had cervical radiographs available within the 2 years before the intervention. Table 1 shows patient characteristics, duration of RA, types of intervention (surgery or other procedure), airway class and grade, and airway management techniques in those who underwent cervical radiographic assessment and in those who did not. No associations were observed between use of radiographs and patient characteristics, or type of intervention.

Radiographs in the 176 RA patients who underwent airway management were considered to be a) complete in 7 (4%), b) adequate in 33 (19%), c) semiadequate in 16 (9%), and d) inadequate in 32 (18%); no cervical spine radiographs were available for 84 patients (48%). Four patients (2%) had a radiological report but no scanned images for us to review.

Of the 92 patients with available radiographs, 18 (20%) had radiological evidence of cervical spine abnormality. Three (17%) had surgical fusions and 14 (78%) had subaxial displacements or listhesis. All the subaxial displacements had a malalignment of less than 4 mm. Only 1 patient showed AAS measured by the anterior atlantodental interval (4.9 mm). However, the posterior atlantodental interval was 18 mm (Fig. 1). Table 2 shows

TABLE 1. Patients' Characteristics and Airway Management According to Prior Availability of Radiographs

	First Surgery/Procedure With Airway Management for Each Patient		
	Preoperative Radiograph (n = 92)	**No Preoperative Radiograph (n = 84)**	***P***
Age, mean (SD), y	62.9 (10.9)	62.9 (11.9)	>0.9
Female, n (%)	64 (70)	55 (65)	0.6
Duration of RA,[a] n (%), y			
<2	8 (11)	11 (21)	0.2
2–5	19 (25)	9 (17)	
>5	49 (64)	33 (62)	
Surgeries, n (%)			
Gastrointestinal (row percentages)	14 (58)	10 (42)	0.8
Genitourinary (row percentages)	11 (44)	14 (56)	
Head and Neck (row percentages)	28 (54)	24 (46)	
Skin/lymphatic (row percentages)	14 (50)	14 (50)	
Others (row percentages)	24 (59)	17 (41)	
Procedures (nonsurgical), n (%) (row percentages)	1 (17)	5 (83)	0.7
Oropharyngeal class,[b] n (%)			
Class I	19 (23)	19 (28)	0.7
Class II	49 (60)	36 (53)	
Class III	14 (17)	13 (19)	
Class IV	0 (0)	0 (0)	
Glottic visualization grade,[b] n (%)			
Grade I	42 (67)	33 (65)	
Grade II	21 (33)	18 (35)	
Grade III	0 (0)	0 (0)	0.8
Grade IV	0 (0)	0 (0)	
Airway management, n (%)			
Endotracheal tube	78 (84)	69 (82)	0.6
Fiber-optic intubation	7 (8)	10 (12)	
Laryngeal mask airway	7 (8)	5 (6)	

[a]Data on duration of RA were available for 129 of the 176 patients.

[b]Data on oropharyngeal class and glottic visualization grade were available for 150 and 114 first surgeries/procedures with airway management, respectively, but all patients had at least 1 of the 2 measures available.

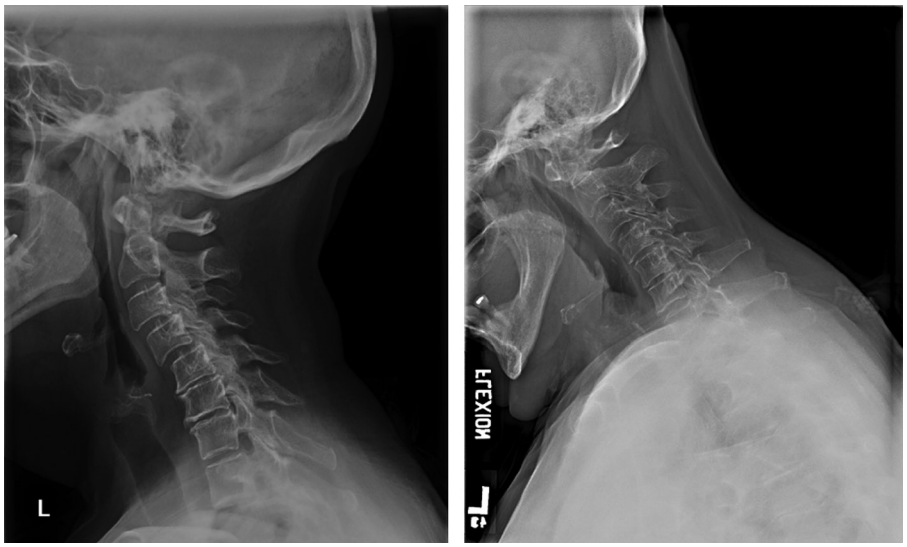

FIGURE 1. Cervical instability. Left, Subaxial displacement (3.5 mm anterolisthesis of C3 vertebral body on C4 and 5 mm anterolisthesis of C4 on C5). Right, Only AAS found in the study (4.9 mm).

TABLE 2. Characteristics and Airway Management in Patients With and Without Radiographic Abnormalities

	Radiographic Abnormalities (n = 18)	No Radiographic Abnormalities (n = 74)	*P*
Age, mean (SD), y	65.7 (11.7)	62.3 (10.7)	0.2
Female, n (%)	11 (61)	53 (72)	0.4
Duration of RA,[a] n (%), y			
<2	2 (12)	5 (9)	0.5
2–5	4 (23)	15 (26)	
>5	11 (65)	38 (65)	
Type of intervention, n (%)			
Gastrointestinal (row percentages)	2 (14)	12 (86)	0.4
Genitourinary (row percentages)	3 (27)	8 (73)	
Head and neck (row percentages)	5 (18)	23 (82)	
Skin/lymphatic (row percentages)	2 (14)	12 (86)	
Other (row percentages)	5 (21)	19 (79)	
Oropharyngeal class III or IV, n (%)	5 (33)	9 (13)	0.2
Glottic visualization grade III or IV, n (%)	0 (0)	0 (0)	NA
Airway management,[a] n (%)			
Endotracheal tube	15 (83)	63 (85)	0.1
Fiber-optic intubation	3 (17)	4 (5)	
Laryngeal mask airway	0 (0)	7 (10)	

[a]Data on duration of RA were available for 75 of the 92 patients.

[b]Data on airway class and grade were available for 150 and 114 first surgeries/procedures with airway management, respectively.

NA, not applicable.

characteristics and airway management in the 92 patients with radiographs according to whether they had abnormalities. Head and neck–related surgeries were the most frequent procedure for both patients with and without abnormalities (54% vs. 46%). Fifteen (83%) of the 18 patients with abnormalities and 63 (85%) of the 74 patients without abnormalities underwent direct laryngoscopy with endotracheal tube, suggesting that preoperative radiographic assessment did not modify airway management.

We used multivariate analysis to determine the influence of various factors on (1) radiograph use and (2) anesthesia delivery techniques. Data on oropharyngeal class and glottic visualization grade were not available for each patient, but at least one of these data was documented so we considered patients to have potentially difficult airway management if either airway class or grade was III or IV. Use of radiographs was not associated with age, sex, or disease duration (data not shown). For patients undergoing airway management, the use of fiber-optic intubation or laryngeal mask was only associated with the presence of a difficult oropharyngeal class or glottic visualization grade (i.e., 3 or 4), with an odds ratio of 5.5 (95% confidence interval, 2.1–14.4; $P = 0.001$; Table 3). Prior availability of radiographs or abnormal radiographic results did not influence airway management. Furthermore, the exclusion of patients with surgical fusions and mild displacements (1.0–3.0 mm) from the analysis did not modify our results (data not shown).

A further 65 patients underwent surgery or a procedure with monitored anesthesia care (without airway management). Of these, 19 (29%) had preoperative radiography: 3 (5%) had open-mouth odontoid views available and 8 (12%) had inadequate radiographs. Six patients (9%) had abnormalities.

No neurological or vascular complications were observed in any of the patients undergoing airway management or monitored anesthesia care.

TABLE 3. Multivariate Regression Model for Determinants of Airway Management: Use of Laryngeal Mask or Fiber-Optic Intubation Versus Rigid Endotracheal Intubation

	OR (95% CI)	*P*
Age, y	1.0 (1.0–1.1)	0.08
Sex (male)	0.4 (0.1–1.1)	0.06
Radiograph result (normal)		
Abnormal radiograph	1.0 (0.2–3.8)	0.8
No radiograph	1.3 (0.5–3.2)	0.6
Oropharyngeal class/glottic visualization grade (I or II)		
III or IV	5.5 (2.1–14.4)	0.001

Reference group in parentheses.

CI, confidence interval; OR, odds ratio.

DISCUSSION

To our knowledge, this is the first study to evaluate the use of radiographs and airway management in patients with RA undergoing general surgery and procedures with anesthesia. All prior studies have been conducted in patients undergoing orthopedic surgery, and in this setting, practice patterns may be different because orthopedic surgeons may have different awareness or perceptions about cervical problems in RA patients than general surgeons do. Our study was conducted in the largest cancer center in the United States, which performs more than 14,000 surgeries and procedures under anesthesia per year, staffed by 64 anesthesiologists. We found that half of the RA patients undergoing anesthesia had no prior cervical radiographic evaluation. Furthermore, most radiographs obtained were not considered adequate to assess AAS: only 4% of the radiographs available in patients undergoing airway management were considered complete and

19% were adequate. Of the patients who underwent preoperative radiographic evaluation, 20% had cervical abnormalities, but these results did not influence airway management. Patients with an oropharyngeal class or glottic visualization grade of 3 or 4 were 5.5 times more likely to undergo anesthesia with fiber-optic intubation or laryngeal mask than those with grade or class 1 or 2, suggesting that the anesthesiologist airway evaluation was the only relevant factor in determining subsequent airway management.

The prevalence of cervical spine involvement in the current study was similar to that observed in other cohorts (20%–25%).[13,20,21] Four studies have previously evaluated the use of radiographs in patients with RA, undergoing surgery, but they were all for orthopedic procedures. Campbell et al.[22] reported a prevalence of 16% cases (20/128) with cervical instability or previous spinal fusion. The authors found that seventy percent of the patients with instability or previous fusion had at least 1 previous radiograph examination of the cervical spine. The incidence of previously undetected instability (7/128) was 6%. In the 19 with documented cervical instability, 37% underwent laryngeal intubation; and the remainder, other techniques. White et al.[23] observed listhesis on 9% (23/258) of the patients. The cervical radiographs were evaluated in preoperative planning but did not alter the surgical treatment. Both studies concluded that radiographs were no longer recommended as a useful part of the initial anesthesia evaluation in patients with RA. Another study by Kwek et al.[13] found that the presence of cervical spine subluxations favored techniques that avoided unprotected manipulations of the neck, suggesting that preoperative screening might be useful. Neva et al.[16] also recommended preoperative cervical spine screening because they observed asymptomatic cervical spine subluxation was common in 44% (67/154) of patients with RA waiting for orthopedic surgery, most commonly in those who were older, had longer disease duration, had more active disease, had poorer function, and had erosive disease.

The contrasting results found in the literature lead to argue if there is any value in radiographic screening in RA patients before undergoing surgery. While this practice probably serves to heighten the surgical team's awareness of the potentially increased vulnerability of the cervical spine to trauma, in the present study, we found that the cervical spine stabilization and intubation techniques were not modified regardless of the extent of radiographic changes. This might be explained because of the lack of standardization for the management of RA patients, the time limitations during the procedure (fiber-optic intubation requires skill, experience, and time compared to endotracheal intubation). Many anesthesiologists are more comfortable with the use of direct laryngoscopy and endotracheal intubation with manual in-line stabilization of the cervical spine. However, positioning (extension/flexion) of the cervical spine during laryngoscopy may cause spinal cord trauma. In case of advanced lesions in the atlantoaxial joint, even slight motions of the head may cause compression of the spinal cord, medulla, or vertebral arteries, causing pyramidal symptoms, quadriplegia, or, occasionally, sudden death. In patients with suspected cervical spine instability undergoing surgery, alternative airway management techniques that do not involve neck manipulation, such as fiber-optic intubation, might be more appropriate. Hakala and Randell[9] compared endotracheal intubation with a rigid laryngoscope with the use of a fiberscope in patients with RA. Major difficulties in endotracheal intubations were encountered in 13% of patients managed with rigid laryngoscope and in 8% in the fiberscope group. Tracheostomy was needed only in the group under rigid laryngoscope (2/41). No complications were reported for the group with fiberscope, but prolonged intubations were observed owing to lack of experience. Wattenmaker et al.[24] also examined the perioperative airway complications in patients with RA undergoing orthopedic surgery. Non–fiber-optic intubation was a significant risk factor for upper airway obstruction developed after extubation, even when adjusting for the difference in the lengths of time to extubation. The authors concluded that complications can be minimized with fiber-optic management of the airway.

Although neurological deficits have been reported in 10% to 36% of RA with cervical spine involvement[4,25] after surgery, we did not observe any neurological complications among the patients reviewed in our study. Evidence suggests that AAS greatly increases the risk of developing cord compression, but it is not possible to predict which patients will develop complications. Rheumatoid arthritis patients may benefit from careful and continuous neurological evaluation before, during, and immediately after surgery to decrease the risk for neurological complications.

Our study had several potential limitations. First, our study participants were patients with both RA and cancer, and airway management may be more difficult in subsets of this population, specifically in head and neck surgeries, because of tumor mass, prior surgery, or radiation fibrosis. Second, because the postoperative evaluation of potential complications was based only on the discharge summary, the data collected were limited to the available documentation, and this may not reflect in its totality any event presented after discharge. Also, we had insufficient clinical data in the medical records to evaluate the severity of RA, or disease activity, which may have influenced the use of radiographs and airway management. Third, anesthesia protocols vary among institutions, and the chosen management depends on the preferences of individual anesthetists. Thus, management can vary within the institution; this reinforces the need for standardized assessment. Finally, we cannot evaluate the thought processes of the anesthesiologists at the time of preoperative assessment or surgery. However, the purpose of our research was to conduct an observational study to examine practice. Our institution uses an electronic medical record where all tests and imaging reports and actual images are available for review at the time of patient-clinician encounters, including anesthesia assessments. Our study shows that, in "real-practice" situations, the availability of radiographs at the time of the preoperative evaluation or before surgery did not influence anesthesiologists' use of airway management techniques. A prospective follow-up of the patients or physicians was not performed; therefore, direct ascertainment of patient status or procedures could not be determined.

Our findings suggest that cervical spine abnormalities are not unusual among RA patients undergoing surgery, but that not all patients undergo radiographic assessment before surgery and that the presence of abnormalities do not necessarily modify airway management. Use of clinical evaluation tests such as those reported by Sharp and Purser[26,27] in the preoperative assessment may not prove helpful because these require practice to perform and in themselves can produce injury when performed by untrained hands (could minimize the number of radiographs necessary to monitor cervical spine disease progression). Furthermore, it could be argued that the use of laryngeal mask or fiber-optic intubation should be indicated for most patients with RA, averting the need for prior radiograph screening.

We believe that further studies are needed to prospectively evaluate the real benefit of radiographic evidence in the preoperative assessment of patients with RA and to identify other factors that may influence the anesthesia technique delivered. Thus, the variations in practice highlight the importance of obtaining consensus from rheumatologists, radiologists, anesthesiologists, and surgeons in establishing recommendations for safe and cost-effective perioperative management of RA patients undergoing anesthesia with airway management.

KEY POINTS

1. Cervical instability is not unusual among patients with RA undergoing general surgery.
2. Almost half of the patients with RA undergoing general surgery did not receive preoperative radiographic screening, and when available, less than a third were classified as adequate.
3. Indications for airway management varied according to surgeon and anesthesiologist.
4. Guidelines for the perioperative evaluation of these patients are needed. Rheumatologists should actively participate in the development of such guidelines.

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