Tracheal Configuration as a Radiographic Predictor of Difficult Tracheal Intubation in Goiters

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ABSTRACT

Background: *Goiters producing tracheal deviation or tracheal narrowing (TN) or both may cause difficult tracheal intubation (DTI). This study is to determine whether pre-operative assessment of trachea on neck radiograph can serve to predict DTI in goiters*

Methods: *Pre- thyroidectomy radiographs of 160 patients were retrospectively studied for tracheal narrowing and deviation. Patients' clinical and surgical data including Anaesthesiologists' documented intubation experiences were also evaluated. Tracheal narrowing and relative sizes of the goiter were assessed on frontal and lateral neck radiographs. . Goodman Kruskal Tau cross tabulation analysis with SPSS 11.0 for windows was used to correlate TN to Anaesthetists operative reports of ease or difficulty of intubation.*

Results: *Coronal and sagittal tracheal diameters ranged between 3mm to 27mm. It was less than 7mm in one or both planes in 21 (13.2%) of patients and all had DTI, P = 0.019. The length of TN did not show significant statistical correlation to DTI, P = 0.791. The only two patients having coronal or sagittal tracheal diameter less than 5mm, had failed intubation and surgery was done using bilateral superficial cervical plexus block.*

Conclusions: *Goiters producing luminal TN of less than 7mm have potential for DTI and failed intubation when less than 5mm.*

Key words: ***Goiter, Difficult intubation, plain radiograph, thyroidectomy, Trachea***

INTRODUCTION

Difficult tracheal intubation (DTI) defined as inadequate exposure of the glottis by direct laryngoscopy[1-8] may be caused by an enlarged thyroid gland producing tracheal deviation (TD) or tracheal narrowing (TN) or both[1-4,9]. Among other determinants of DTI are restricted head and neck extension; decreased mento-hyoid distance (mandibular space); short sternomental distance; short thyromental distance; poor Mallampati oropharyngeal class; large neck circumference; receding mandible; and prominent teeth[1-18].

Management of the difficult airway in the general surgical population has been widely studied[1-18], and several clinical scoring criteria that include the Mallampati scoring system have been established[4-14]. The incidences of DTI and failed intubation in surgical patients undergoing general anaesthesia are estimated to be approximately 1–18% and 0.05–0.35% of patients respectively[6,17]. DTI is a cause of morbidity and mortality in anaesthetized patients[1-4, 9,12,14].

Imaging modalities such as ultrasound, plain radiograph, computer tomography (CT) and magnetic resonance imaging (MRI) can provide useful guidance for surgical planning in goitres with specific advantages and limitations. Ultrasound, which is cheap and readily available is operator dependent and cannot image the airways in profile with a hardcopy for surgeons' and Anaesthetists' reference at surgery. On the contrary CT and MRI, which are capable of imaging the airways in its entirety and in three dimensions to provide excellent road map for surgical plan, are still relatively scarce and expensive in many developing countries where large goiters are relatively common[16].

Despite consensus that thyroid surgery is a risk factor for difficult airway management[1-4,9,16,17], availability of a wide range imaging armamentarium for the evaluation of thyroid patients and recognition of the place of radiographic investigations in predicting DTI as early as

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1956[8,13-15], we are unaware of radiological studies or determinants focused on DTI in patients with goiter in the literature. Thus, making allowance for imaging limitations imposed by resources, this retrospective study examined pre-thyroidectomy tracheal configuration as a definite radiographic factor(s) to predict DTI among patients with goiters.

METHODS

The hospital ethics and research requirements were met before commencing this study. A consultant Radiologist unaware of the surgical and anaesthetic histories of patients retrospectively reviewed neck, thoracic inlet and chest radiographs, which are routinely done for surgical goiters in our centre prior to thyroidectomy for TN and TD between January 1998 and December 2006. Since our centre has protocol focus-object-film distance for neck and chest radiography, we assumed there is projection uniformity for images studied and exclusively limited it to radiographs emanating from our centre.

Radiographs of 184 patients with clinically palpable goiters were available for review, but only 160 patients who had thyroidectomy under general anaesthesia or attempted general anaesthesia were included in the final analyses. We also reviewed the patients' case files for demographic data, clinical notes (including operation note and anaesthetic notes). Cases with DTI were identified and related to the plain radiographic tracheal changes. Intubations carried out by a senior anaesthetist requiring more than three attempts or a change in the materials used to intubate were defined as DTI. Thus, we evaluated only the tracheal parameters and assumed that all other determinants of DTI, such as hyomental, thyromental and sternomental distances; neck extension; and Mallampati scores that could cause inadequate exposure of the glottis during direct laryngoscopy as normal where not mentioned in the anaesthetists' notes. Various grades of Anaesthetists from the rank of senior registrar carried out the endotracheal intubation but a consultant anaesthetist was always in attendance. The anaesthetists adhered strictly to the protocol of using endotracheal tubes sizes 5.0 mm-7.0 mm for intubation in goiters to minimize post-operation tracheal mucosal oedema from frictional effect when the gland is manipulated.

The presence of radiographic thyroid gland calcifications and thoracic extension (retrosternal goiter) were evaluated and related to TN using cross tabulation analysis. The width of TN was determined at the narrowest segment along the tracheal coronal plane. The length of narrowing was taken as the distance between the points of tangency of two lines drawn parallel to the upper and lower normal portion of the trachea on the same side with the narrowed tracheal segment at the centre (Fig. 1). We assumed significant tracheal narrowing where the column of tracheal lucency is less than 10mm using Breatnach et al's[19] lower limit of tracheal diameter in female.

Tracheal displacement and relative sizes of the goiters were assessed (Fig. 2A&B). Using the cervical spinous processes as reference point, where radiographic positioning is adequate, tracheal with more than 75% of its column of lucency projecting lateral to the spinous processes were labelled as laterally deviated or displaced. The relative sizes of the goiters were assessed using the skin-vertebral distance for all patients [Fig. 3A & B]. We defined skin-vertebral distance by drawing two parallel lines: 1) anterior vertebral line, which is a line tangential and parallel to at least two vertebral bodies between C5 to C7; and 2) skin line, which is a line parallel to the vertebral line and runs tangentially to the anterior outermost part of skin. The perpendicular separation of these two lines is the skin vertebral distance (Fig. 3A & B). The prevertebral space was also determined along the skin vertebral line. Data was analyzed using SPSS 11.0 for windows.

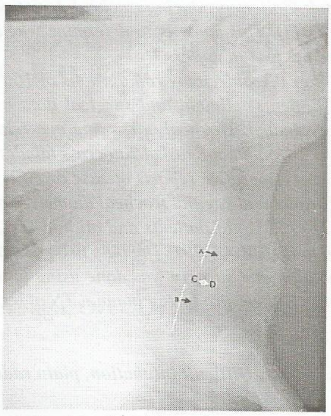

Fig. 1: Lateral neck radiograph demonstrating tracheal narrowing in goiter and the assessment for both length (distance A-B) and width (distance C-D) of narrowing.

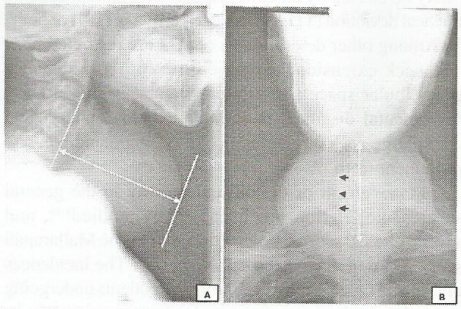

Fig. 2A & B: Lateral and frontal neck radiographs demonstrating effects of goiter on the trachea. [A] Showed minimal tracheal narrowing and measurements of the relative size of goiter and [B] Right side tracheal deviation (black arrows) from midline (white arrow).

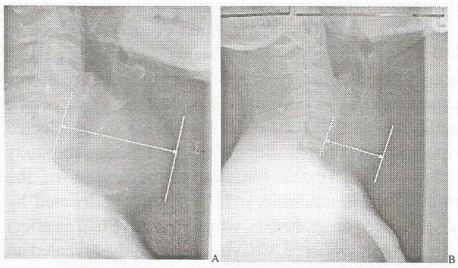

Figure 3A & B: Lateral neck radiographs illustrating measurements of relative goiter sizes in different patients

RESULTS

The patients' ages ranged between 15years to 80 years with a mean age of 41.3 ± 14.1years. Females constituted 85.5% of the total patients giving a male to female ratio of 3:17. Lateral tracheal deviation occurred in 57.6% (n=92), and was to the right in 63% and to the left in 37%. Tracheal narrowing was present in 91.9% of cases. There were sagittal, coronal and annular narrowing in 12.6%, 18.1% and 61.3% respectively. None of the cases reviewed had the dimensions of the tracheal narrowing documented in the patient's radiological report. The diameter of tracheal column of lucency ranged from 4mm to 27mm. The mean length of tracheal narrowing was 52mm ± 34mm with the maximum length been 140mm recorded in a patient. The narrowest coronal tracheal calibre was 3mm and 77 patients (42.2%) had tracheal coronal diameter less than 10mm while the narrowest sagittal tracheal caliber was 4mm [Fig. 4A] with 44 patients (24.0%) having sagittal diameter less than 10mm. In coronal and sagittal planes, TD was less than 7mm in 21(13.2%) and 14 (8.8%) patients respectively (Table I). All patients with either coronal or sagittal tracheal diameter less than 7 mm had DTI, P = 0.019, and delayed post anaesthesia recovery from laryngeal/tracheal mucosal oedema. In two patients with coronal or sagittal TD less than 5mm [Fig. 4A & B and Table I], there was failed intubation and surgery was done using bilateral superficial cervical nerve block. The length of TN, relative size of the goiter and retrosternal extension did not show significant statistical correlation to DTI, P = 0.73.

Annular narrowing predominated in all age groups and in both sexes (58% in males and 70% in female goiters). The tracheal narrowing was annular in goitres with associated kyphosis or scoliosis with significance of 0.001. Where there is retrosternal extension, transverse and annular narrowing occurred in 95.5% of cases, P = 0.001. All cases of goiters with calcifications have varying degrees of tracheal narrowing as shown in Table II (P < 0.0001). However, the presence of calcification in goiters was not significantly correlated to DTI. All our patients had surgery (subtotal thyroidectomy in 89.3%) and histology.

Table II: Calcification in Goiters Related to Tracheal Narrowing

Tracheal Narrowing	Calcifications		Total
	Yes	No	
No narrowing		13	13
Sagittal Narrowing	3	17	20
Coronal Narrowing	5	24	29
Annular Narrowing	20	78	98
Total	**28**	**132**	**160**

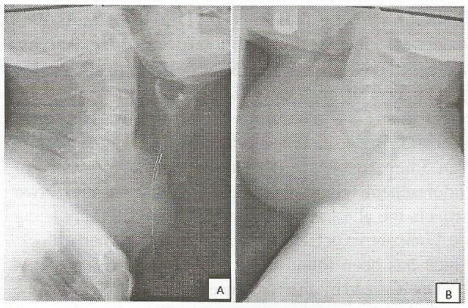

Figure 4A & B: Lateral neck radiographs of two patients with tracheal column of lucencies (tracheal internal diameter) less than 5mm. Both patients had failed intubation. Note the marked tracheal compression and narrowing from goiter in both patients.

Table I: Plain Radiographic Tracheal Diameter Related to Anaesthesiology Intubation Experiences

Tracheal lucency (internal diameter in mm)	Frequency (n) Frontal Radiograph (Coronal Distribution)	Lateral Radiograph (Sagittal Distribution)	Anaesthetists' Assessment Difficult intubation	Failed intubation	Normal intubation
Less than 7	19	11	17	2	-
7-13	83	68	2	-	66
14-20	57	78	-	-	78
Greater than 20	1	3	-		3
TOTAL	**160**	**160**	**21**	**2**	**147**

DISCUSSION

DTI is expected when goiters are associated with airway deformities [Fig. 2A &B and 4A & B]. The few radiologic studies to predict DTI in the general surgical patients have used complex mathematical scores and drawings[8,13-15]. To the best of our knowledge, none has evaluated the place of tracheal configuration as a determinant of DTI in goiters. Therefore, this study evaluating TN and TD on frontal and lateral neck radiographs for predicting DTI in goiters is the first of its kind. Previous studies to predict DTI in surgical patients have attempted to create a scoring system[5-14] or a complex mathematical model[7,8,13-15] because initial studies (all clinical) that compared individual parameters to predict DTI were with mixed results[5-13].

Since surgical intervention under general anaesthesia is generally regarded as the treatment of choice for most goiters[9,16,17], our assessment of TN, which essentially assesses the internal tracheal diameter (column of tracheal lucency), will be of value to the anaesthetists and the surgeons in both anticipatory and decision-making. In this study, all patients with either coronal or sagittal tracheal diameter less than 7 mm (13.2%) had DTI (P = 0.019) and delayed post surgery recovery. This is similar to 12.7% findings in a study by Chaves et al's[1] where a retrospective evaluation of the incidence of DEI in patients who underwent elective thyroid surgery was done. Varying degrees of pressure symptoms during mobilization of the gland may probably account for post operation morbidity rather than DTI in some of these patients. The failed intubation in two patients with coronal or sagittal TD less than 5mm [fig. 4A & B] may be related to the size of endotracheal tubes available for adults. In these two patients the alternative option was thyroidectomy using local anaesthesia or bilateral superficial cervical nerve block, which has been found to be safe in poor risk patients when performed by an experienced surgeon[6,16,17]. Probably, surgical goiters with radiographic TN where internal tracheal column of lucency is less than 7mm, local anaesthesia or bilateral superficial cervical nerve block should be considered rather than general anaesthesia with endotracheal intubation to reduce post-operative morbidity. However, prospective studies will be required to validate this assertion. In facilities where available, fibreoptic aided intubation under local anaesthesia of the pharynx, larynx, trachea and the tongue as described by Wakening et al[20] may be another option when DTI is expected.

Amongst a population of 320 patients that had thyroidectomy for goiter, Bouaggad et al's[2] recorded an incidence of DTI of 5.3% and this was commoner in patients with malignant thyroids. DTI of 13.2% encountered in this study is much higher. However, Amathieu et al[3] found out that the presence of thyroid malignancy was not related to an increased DTI that was significantly different from the control group. The main limitation of Bouaggad et al's[2] study was the absence of a control group unlike in Amathieu et al's[3] study where difficult intubation in goiter patients was compared with those without goiter. Despite the use of a control group, Amathieu et al's[3] were unable to identify any specific predictive risk factor for DTI amongst their selected population of patients with goiters. In addition, the study did not quantify the goiter size and a few of the endotracheal intubations assessed were performed by inexperienced anaesthetists, which may have had an effect on ease of intubation[3]. Chaves et al's[1] study, revealed no risk factors for DTI in 24.6% of the patients that had difficult or very difficult endotracheal intubation and concluded that this implies the existence of false negatives. Before assuming such a conclusion, we advised that there must be radiological exclusion of tracheal configuration abnormality. However, none of the aforementioned studies and the other references reviewed examines the tracheal configuration as a means of predicting DTI. We are not unaware of some of the limitations of our observational study was lack of controls and the reliance on anaesthetist notes. The non-availability of our patients' BMI is also a drawback in this study. Unlike Voyagis et al's[7] reports, Brodsky et al[18] in their study involving 100 morbidly obese patients with interquartile weight, height and BMI ranges of 124kg –156 kg, 160cm –173 cm and 43.9 –56.6 kg/m^2 respectively found no association between increasing weight or BMI with DTI but rather high Mallampati score (greater-than-or-equal to 3) and large neck circumference. We found goiters producing annular luminal TN to less than 7mm in association with DTI and failed intubation when less than 5mm.

CONCLUSIONS

Thyroid enlargement accompanied by airway deformity is a risk factor for DTI. It is possible to predict prior to thyroidectomy from plain cervical radiograph. Goiters producing annular luminal TN to less than 7mm have potential for DTI and failed intubation when less than 5mm.

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