

## Foreign body ingestion: comparison of diagnostic accuracy of computed tomography versus endoscopy

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### Abstract

**Purpose:** To investigate and compare the sensitivity and specificity of computed tomography and of endoscopy, as diagnostic tests for foreign body ingestion.

**Materials and methods:** Over a two-year period, Asian patients with suspected foreign body ingestion were studied. The clinical findings, computed tomography images, endoscopic results, treatment and outcomes were prospectively analysed.

**Results:** Over the study period, 193 patients were admitted for foreign body ingestion, complaining of a persistent foreign body sensation in the neck. The sensitivity and specificity of computed tomography were 78 and 96 per cent, respectively; the positive predictive value was 75 per cent and the negative predictive value 97 per cent. The diagnostic accuracy of computed tomography was 94 per cent.

**Conclusion:** Our study showed that computed tomography had high negative predictive value and accuracy in the diagnosis of foreign body ingestion. It was useful if endoscopy showed negative findings but the patient still had persistent symptoms of foreign body ingestion.

**Key words:** Pharynx; Foreign bodies; Endoscopy; Computed Tomography

### Introduction

Foreign body ingestion accounts for a significant number of emergency admissions to surgical units. Endoscopy is suggested for patients with a persistent foreign body sensation after an apparently negative radiographic evaluation.<sup>1,2</sup> However, the use of endoscopy as a diagnostic tool was reported to be associated with a 0.2–2 per cent risk of oesophageal perforation.<sup>3</sup> In our centre, 1338 patients were admitted for suspected foreign body ingestion from 1996 to 2000.<sup>4</sup> All patients underwent endoscopic examination; 30 per cent were positive for a foreign body while 70 per cent were negative. Endoscopy-related complications occurred in 0.8 per cent of patients. However, the role of computed tomography (CT) was at that time still undefined, even in studies of selected groups of patients with high diagnostic yields.<sup>5,6</sup> Hence, this study aimed to establish the diagnostic accuracy of CT, and on this basis to define the role of CT in the management of foreign body ingestion.

### Materials and methods

#### *Patients*

The medical ethics committee of our hospital approved the protocol for this prospective study.

All patients gave informed, written consent for the endoscopy and CT scan. From March 2003 to March 2005, patients admitted with a provisional diagnosis of suspected foreign body ingestion were included in our study. The exclusion criteria comprised: (1) patients with a foreign body who were at risk of aspiration, for whom urgent endoscopy was required; (2) patients with a suspected or identified complication (e.g. abscess or surgical emphysema); (3) patients with a foreign body identified by plain radiography or direct laryngoscopy; (4) those for whom informed consent was unavailable; and (5) asymptomatic patients. All patients were followed up either in the out-patient clinic or by telephone interview in the four weeks after discharge.

#### *Computed tomography*

All recruited patients had CT studies arranged within four hours of admission. Patients were examined supine in the scan region C3 to T1<sup>7</sup> using a helical CT scanner (High Speed Advantage; GE Medical System, Milwaukee, Wis). The tongue base and oropharynx were not included in the CT study as direct laryngoscopy in the emergency department was expected to rule out any foreign body in this region, and a shorter CT range entailed less radiation

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exposure for the patient. The CT parameters were: 120 kVp, 150 mAs, 5 mm collimation and 5 mm reconstruction without overlap.

The images were then reviewed by one of two radiologists (WCF, with 14 years of radiology experience, or RYYC, with 15 years of radiology experience) and the written reports placed in sealed envelopes. The identification of a high density foreign body signified a positive CT finding of foreign body ingestion. If there was no radiopaque foreign body, this was considered to be a negative finding; however, detection of an indirect sign (e.g. focal oedema, soft tissue swelling or haematoma formation) would also be recorded to facilitate subsequent search for foreign bodies by the surgeons. Another radiologist (WHL), who was blinded to all previous results, reviewed all images. Any disagreement was discussed.

### Endoscopy

All patients with persistent symptoms underwent endoscopy performed by one of the endoscopists (KHT or SWWC, both with four years of endoscopy experience) within 12 hours of admission. After the procedure, the endoscopist cross-checked the CT result from the sealed envelope, and these results were used as additional information in managing the suspected foreign body ingestion. Therefore, the CT results were made known to the endoscopist after they had recorded their findings, but before withdrawal of the endoscope, in order to prevent any unnecessary re-endoscopy. All retrieved foreign bodies were collected for CT Hounsfield unit measurement and dimensional analysis.

### Patient tolerance and outcome

After the CT scan and endoscopy, each patient was given a simple questionnaire containing a linear visual analogue scale (using five grades, with grade five indicating the most satisfaction and grade one the most discomfort). All patients were followed up four weeks later (see Figure 1).

### Statistical analysis

Data were analysed using the statistical analysis software (SAS), version nine. The sensitivity, specificity, positive and negative predictive values, and diagnostic accuracy of CT in diagnosing suspected foreign body ingestion were calculated and compared with those of endoscopy, using the final clinical outcome as the 'gold standard'. The paired *t*-test was used to assess patients' tolerance of CT scanning and endoscopy. The kappa test was calculated to assess inter-observer agreement between the two radiologists. A result of  $p < 0.05$  was considered to represent a statistically significant difference.

### Results

During the two-year study period, 193 patients were recruited (Table I). The male to female ratio was 76:122, and patients' mean age was 41 years (range 18 to 85 years). Patients' symptoms of foreign body

ingestion lasted for a period of zero to 11 days, with a mean of 2.2 days.

There were 155 patients with a final diagnosis of no foreign body, confirmed by clinical follow up. Of these 155 patients, six were suspected of foreign body ingestion based on CT scanning but proven negative by endoscopy and clinical follow up. A total of 38 foreign bodies were discovered (Table II, Figure 2), ranging in length from 0.3 to 4 cm. The CT radio density values for these foreign bodies ranged from 33 to 135 Hounsfield units. Eighteen patients had positive results for both CT scanning and endoscopy. The vallecula and pyriform fossa were the most common sites for foreign body ingestion (Table III). Twenty patients had negative CT results but subsequent positive endoscopy results.

The sensitivity and specificity of CT scanning were 47 per cent (18/38) and 96 per cent (149/155), respectively. The positive predictive value and negative predictive value were 75 per cent (18/24) and 88 per cent (149/169), respectively (Table IV). However, on review of the CT images and endoscopy findings, 15 patients were identified as having foreign bodies lodged outside the CT scan region (Table V). When these 15 patients were excluded from analysis, there were only five patients with negative CT scans but foreign bodies discovered on endoscopy (Table VI). Therefore, the adjusted sensitivity and specificity of CT scan detection of foreign body ingestion were 78 per cent (18/23) and 96 per cent (149/155), respectively. The adjusted positive and negative predictive values were 75 per cent (18/24) and 97 per cent (149/154), respectively (Table VII). The adjusted accuracy was 94 per cent (167/178).

Of the six cases with positive CT results but negative endoscopic findings, four were concluded to be due to CT artefacts or normal variation (Figures 3 and 4). One foreign body was missed by the initial endoscopy, but repeat endoscopy revealed a foreign body impacted at the cricopharyngeus (Figure 5). The remaining case was possibly due to dislodgement of the foreign body during the waiting time between CT scanning and endoscopy.

Very good agreement was found between the two radiologists' records; only three cases out of 193 generated initial disagreement, which was resolved after discussion. The kappa value was 0.93, indicating strong agreement.

Patients' tolerance of CT scanning was much greater than that of endoscopy ( $p < 0.01$ ). All patients were discharged within two days of admission, and their throat discomfort resolved over the four-week follow-up period. There was no record of any associated mortality.

### Discussion

Foreign body ingestion accounts for a significant number of emergency admissions to surgical units. The diagnostic accuracy of plain radiography has been found to be low.<sup>7,8</sup> Endoscopy is the traditional gold standard for diagnosis of suspected foreign body ingestion. However, this procedure is invasive, and is

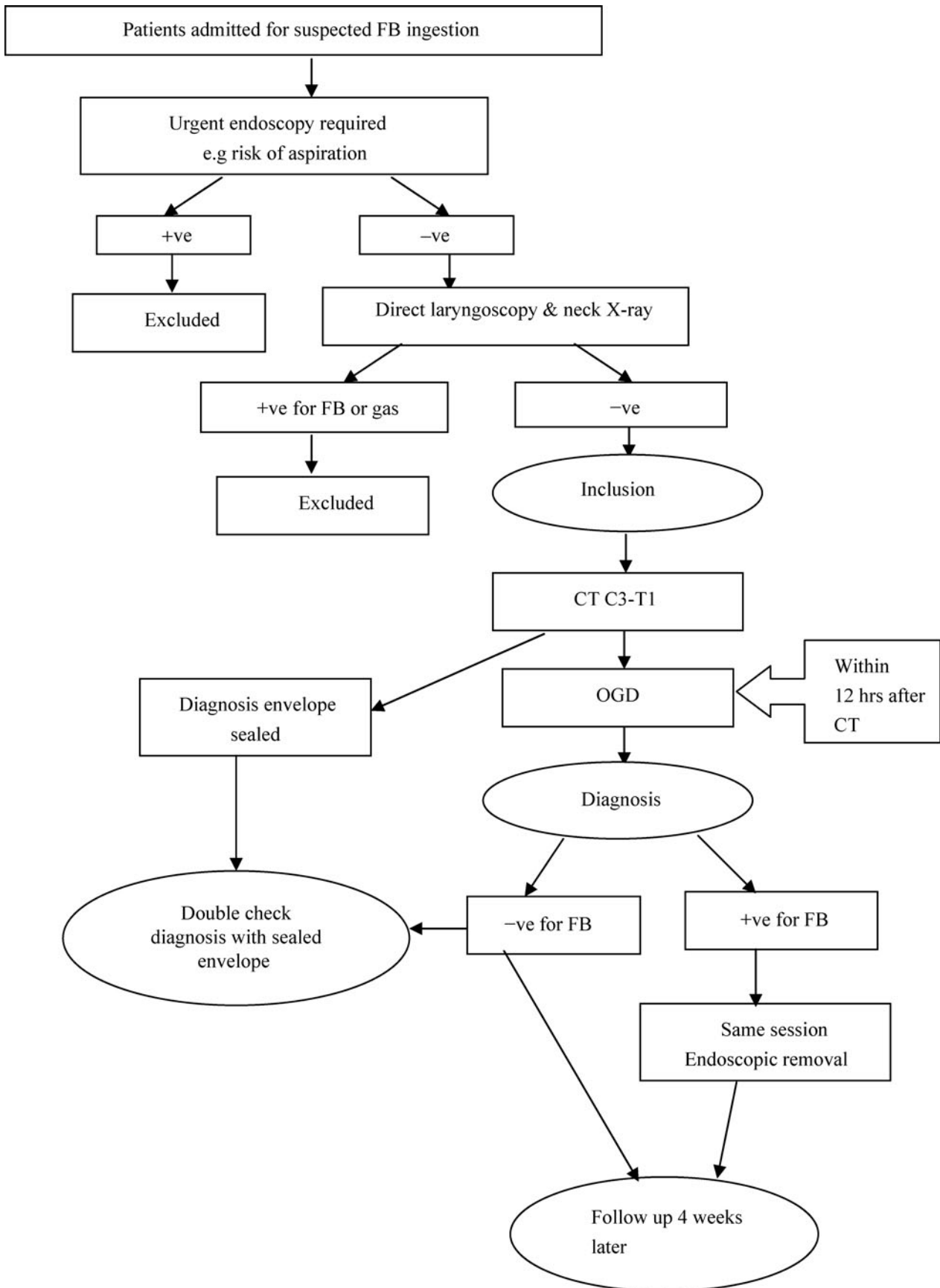


FIG. 1

Flow chart of study stages. FB = foreign body; +ve = positive; -ve = negative; CT = computed tomography; OGD = oesophagogastroduodenoscopy.

TABLE I  
SUMMARY OF RESULTS

Total patients recruited ( <i>n</i> )	193
Male to female ratio	71:122
Mean age (years)	41
Symptom duration (range (mean); days)	0–11 (2.2)
Foreign bodies diagnosed ( <i>n</i> )	38
Mean CT tolerability*	4.3
Mean endoscopy tolerability*	2.3
Complications ( <i>n</i> )	0

\*On a scale of 1 to 5. CT = computed tomography

also associated with a 0.2–2 per cent rate of oesophageal perforation.<sup>3</sup> From 1996 to 2000, 1338 patients were admitted to our centre with suspected foreign body ingestion.<sup>4</sup> All underwent endoscopic examination; 401 (30 per cent) cases were positive for foreign body ingestion and 937 (70 per cent) were negative. Nine (0.7 per cent) cases had a missed or uncertain diagnosis. Ten cases (0.8 per cent) suffered endoscopy-related complications. If there existed another, non-invasive investigation with comparable sensitivity and specificity, then approximately 70 per cent of endoscopies could be avoided.

The role of CT in the investigation of foreign body ingestion has hitherto been undefined, although previous studies have shown its high diagnostic yield, with some suggesting that it could replace endoscopy in initial patient screening.<sup>5,9</sup> In a recent article and literature review, Debasis commented that CT scanning was much more useful than plain radiography in the diagnosis of foreign body ingestion, as its sensitivity was as high as 100 per cent, even with the use of single slice CT with 3 to 5 mm slice thickness.<sup>10</sup> Both the specificity and positive predictive value of CT in such cases are high (approaching 100 per cent). The present study aimed to compare the accuracy, safety and tolerability of CT and endoscopy in the diagnosis and management of oesophageal foreign body ingestion in a Chinese population, after exclusion by plain radiography.

As in our centre's previous study,<sup>4</sup> most of the foreign bodies encountered (68 per cent) were fish bones. Moreover, none of the fish species most commonly eaten in Hong Kong (notably grass carp, goldfish, garouper and golden thread) has been encountered in previous studies undertaken in Western countries.<sup>11</sup> This higher prevalence of fish bones as foreign bodies amongst Chinese patients can be explained by the fact that Chinese diners use their teeth, tongue and lips to separate fish

TABLE II  
TYPES OF FOREIGN BODY INGESTED

Foreign body	Patients ( <i>n</i> (%))
Fish bone	26 (68)
Chicken bone	4 (10)
Pork bone	6 (16)
Crab shell	2 (5)
Total	38

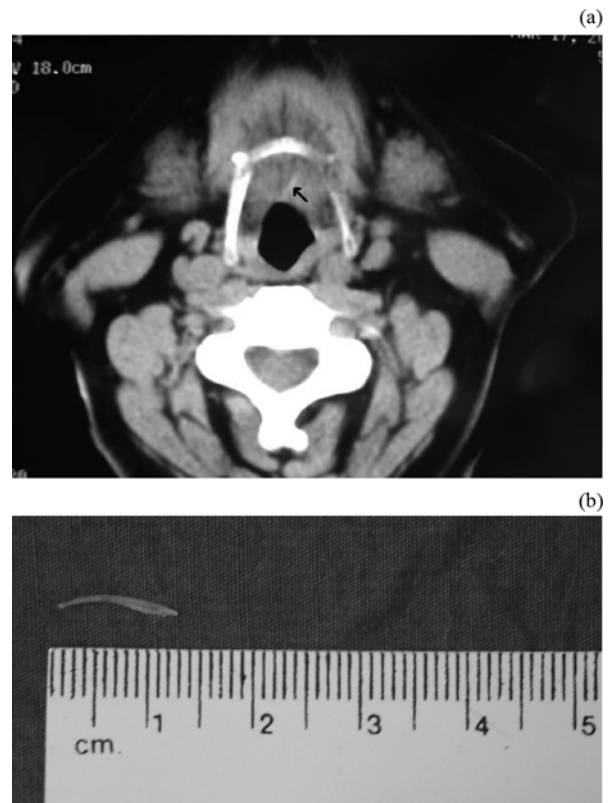


FIG. 2

(a) Transverse computed tomography image showing a linear hyperdensity at the hypopharynx at the level of the hyoid bone (arrow); endoscopy identified this as a foreign body. (b) Fish bone removed at endoscopy, measuring approximately 1.2 cm long.

meat from the bone, in their mouths; also, fish is preferred to be served with the bones intact.<sup>12</sup>

In contrast with other studies finding a high positive predictive value for CT detection of foreign body ingestion, our study revealed five cases of missed foreign bodies (all fish bones). On reviewing these cases, most involved foreign bodies with Hounsfield unit values similar to or just greater than soft tissue density. Ngan *et al.* note that fish bones ingested by Hong Kong patients are usually radiolucent.<sup>7</sup> In our series, the one missed fish bone with a high Hounsfield unit value was of too small a size (0.3 cm) for our CT scanner to detect. Another, 3 cm long missed foreign body was very thin; this bone may have been missed because of its orientation (e.g. a thin fish bone lying transversely may be missed in a 5 mm CT slide). The use of

TABLE III

ENDOSCOPIC SITES OF FOREIGN BODY INGESTION WITHIN CT RANGE*	
Site	Patients ( <i>n</i> )
Vallecula	6
Pyriform fossa	4
Cricopharyngeus	3
Upper oesophagus	2
Epiglottic fold	3

\*C3 to T1. CT = computed tomography



TABLE IV

FOREIGN BODY DETECTION OUTCOMES FOR CT AND ENDOSCOPY		
	Endoscopy positive	Endoscopy negative
CT positive	18	6
CT negative	20	149

Data represent diagnoses of foreign body ingestion. The use of computed tomography (CT) to detect foreign body ingestion had a sensitivity of 47%, a specificity of 96%, a positive predictive value of 75%, a negative predictive value of 88% and an accuracy of 87%.

newer, multi-slide CT units with multi-planner reconstruction will hopefully eliminate such missed diagnoses.

Inter-observer variation was very low in our study, with only three cases of disagreement (which were due to misreading artefacts as foreign bodies), resolved after discussion. The problem of misdiagnosis of artefacts could be reduced by the use of multi-slice, helical CT.<sup>13</sup> When viewing CT images, an awareness of tonsillar calcifications (which may cause false positive diagnoses) will enhance the accuracy of interpretation.

Our study included 15 cases of foreign bodies lodged outside the CT scan area. As a result, we recommend that any CT used for foreign body screening should scan from the oropharynx to the oesophagus, irrespective of the site of symptoms, in order to improve detection rates.

We found that CT scanning had a high negative predictive value (97 per cent) for detection of foreign body ingestion. This would indicate that CT scanning is useful in cases in which endoscopy is negative but the patient reports persistent foreign body symptoms. In one such case, with positive CT results but negative initial endoscopy, a repeat endoscopy was undertaken after reviewing the CT findings, and the offending fish bone finally located and removed. Computed

TABLE V

ENDOSCOPIC SITES OF FOREIGN BODY INGESTION OUTSIDE CT RANGE	
Site	Patients (n)
Tongue base	3
Oropharynx	9
Tip of epiglottis	1
Mid-oesophagus	2

CT = computed tomography

TABLE VI

ENDOSCOPIC SITES OF FOREIGN BODY INGESTION MISSED BY CT			
Site	Foreign body		
	Type	Size (cm)	HU value
Vallecula	Fish bone	3	90
Left epiglottis base	Fish bone	1	33
Vallecula	Fish bone	2	50
Cricopharyngeus	Fish bone	2	57
Left piriform fossa	Fish bone	0.3	118

CT = computed tomography; HU = Hounsfield unit

TABLE VII

FOREIGN BODY DETECTION OUTCOMES FOR CT AND ENDOSCOPY, EXCLUDING 15 CASES WITH FOREIGN BODY OUTSIDE THE CT RANGE		
	Endoscopy positive	Endoscopy negative
CT positive	18	6
CT negative	5	149

Data represent diagnoses of foreign body ingestion. After exclusion of these 15 cases, the detection of foreign body ingestion by computed tomography (CT) scanning had a sensitivity of 78%, a specificity of 96%, a positive predictive value of 75%, a negative predictive value of 97% and an accuracy of 94%.

tomography is particularly useful in those cases in which the foreign body impacts into the mucosa, resulting in a negative endoscopic result. Therefore, the real value of CT scanning lies in CT-positive

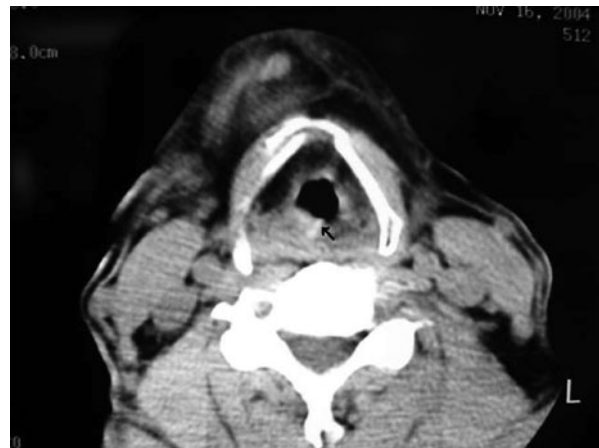


FIG. 3

Transverse computed tomography (CT) image showing a small, linear hyperdensity at the posterior hypopharynx at the level of the hyoid bone (arrow). Endoscopy found no foreign body but identified a small haematoma in the same region. The small hyperdensity seen on CT may have been due to a haematoma left after an impacted foreign body had dislodged.

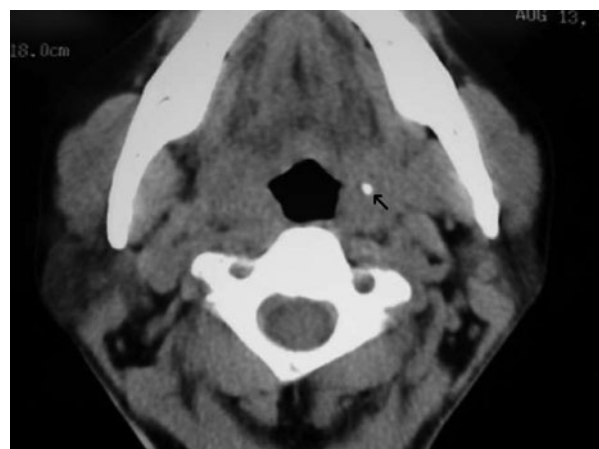


FIG. 4

Transverse computed tomography image showing a small, oval, hyperdense focus at the left oropharynx (arrow), which may have been due to soft tissue calcification. Endoscopy was normal.



FIG. 5

Transverse computed tomography image showing a linear hyperdensity at the cricopharynx (arrow), which was missed at initial endoscopy. Repeat endoscopy revealed a foreign body impacted at the cricopharynx.

cases which were initially endoscopy-negative; the endoscopist can use the CT results to locate the foreign body. Computed tomography is also useful in complicated cases of suspected foreign body ingestion. In our centre's previously reported series,<sup>4</sup> CT scanning enabled the diagnosis of six cases of neck abscess that required exploration and drainage. In this series, we excluded complicated cases in order not to delay management.

- **Pharyngeal foreign body ingestion accounts for significant numbers of emergency admissions**
- **Endoscopy is suggested for patients with a persistent foreign body sensation after an unremarkable radiographic evaluation**
- **This study investigated the use of computed tomography as a diagnostic tool in patients with suspected pharyngeal foreign bodies**
- **Computed tomography had a high negative predictive value and accuracy in the diagnosis of foreign body ingestion. It was particularly useful in patients with persistent symptoms but negative endoscopy**

With the exclusion of complicated cases, our current study showed that both CT scanning and endoscopy are safe in terms of patient morbidity. However, CT is much better tolerated than endoscopy, as it is non-invasive.

## Conclusion

Our prospective study showed that CT scanning has high negative predictive value and specificity in the diagnosis of foreign body ingestion. It is useful if endoscopy is negative but the patient reports persistent foreign body symptoms. The relatively low positive predictive value of CT scanning found in this study, compared with other studies, may be related to the unique fish species consumed by the Chinese population. The positive predictive value of CT for diagnosis of foreign body ingestion may need further clarification in the new era of multi-slide CT units.

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