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ORIGINAL CONTRIBUTIONS

Gastric Banding: Complications Identified by CT

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Abstract

Purpose Laparoscopic adjustable gastric banding (LAGB) used to be a common procedure at the turn of the century and is still frequently encountered on CT scans in common clinical practice. Our aim is to present the frequency and spectrum of complication associated with LAGB, as observed in CT.

Materials and Methods After approval of our institutional review board, a retrospective search for LAGB in CT interpretations using the term "band" between December 2011 and April 2017 was conducted. CT scans were reviewed to identify complications. The findings were divided into two groups: symptomatic, in which the complications caused acute symptoms for which CT scans were conducted, and incidental, in which complications were incidentally identified. The frequency of complications was calculated.

Results We identified 160 patients who underwent LAGB and performed a CT scan. Complications were identified in 69/160 (43.1%) patients, with a total of 83 findings: 47/160 (29.4%) esophageal dilatation, 13/160 (8.2%) pulmonary complications, 6/160 (3.8%) abdominal abscesses, 5/160 (3.1%) small bowel obstructions, 4/160 (2.5%) intragastric band erosions, 4/160 (2.5%) tube disconnections, 3/160 (1.9%) port site and tube course infections, and 1/160 (0.6%) small pouch bezoars. When compared with patients' referral notes, 38/83 (45.8%) of the findings were associated with acute symptoms, whereas 45/83 (54.2%) of the findings were incidental. Eighteen percent of the incidental complications were clinically important.

Conclusion Complications were found in 43% of CT scans of patients who underwent LAGB; less than half of the findings were symptomatic. Some of the incidentally identified complications had substantial clinical importance.

Keywords LAGB, Laparoscopic adjustable gastric banding · CT, computed tomography, complications, band erosion

Introduction

Obesity is associated with reduced life expectancy, increased morbidity, and mortality [1–3].

Bariatric surgery is considered to be most effective treatment for weight loss in severe obesity and its comorbidities [4, 5] especially type 2 diabetes [3, 5, 6]. Bariatric surgery is also reported to be highly cost-effective [6] and has been shown to be to be a reliable long-term solution [7]. Owing to these benefits, the demand for bariatric surgery is rising [8, 9].

LAGB was particularly popular at the turn of the century [10–12], thanks to the minimally invasive nature of this procedure. In this procedure, the surgeon secures an adjustable band in the upper part of the stomach [13] to create a small pouch resulting in early satiety and restricted food intake. The band is attached to a tube connected to a reservoir port placed within the anterior abdominal wall allowing control of the stoma size without the need for surgery [5, 7].

Recent trends indicate a decline in the use of LAGB, and an increase in the use of laparoscopic Roux-en-Y gastric bypass (LRYGB) and laparoscopic sleeve gastrectomy (LSG) procedures [8–10, 12, 14]. This shift in approach is based on up-to-date literature indicating a high rate of revision surgeries for band removal or conversion to different bariatric procedures [10–12, 14–16] as well as studies showing that LRYGB and LSG have significantly greater improvement in weight-loss outcomes in comparison to LAGB [5]. Despite the aforementioned, LAGB is still implemented as a treatment option for severe obesity in some cases [11].

Known LAGB complications include esophageal dilatation, intragastric band erosion, gastric perforation, band slippage, abscess formation, tube disconnection, port-site

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infection, and small bowel obstruction [5, 7, 17–20] as well as respiratory complications including aspiration pneumonia, pulmonary abscess, and empyema (Table 1) [21–23].

The high rate of LAGB complications [10, 19] together with the past popularity of the procedure [9, 11] cause the radiologist to frequently encounter CT scans with LAGB complications, even though this surgery is not the mainstay of bariatric procedures nowadays.

To the best of our knowledge, only pictorial reviews have been published in the radiological literature regarding complications seen after LAGB [7, 17, 18]. This is the first radiologic series summarizing the frequency of CT-identified LAGB complication.

Methods

Our institutional review board (IRB), who waived the need for an informed consent, approved this study. The research adhered to the tenets of the Declaration of Helsinki.

We performed a computerized retrospective search for LAGB in CT interpretations of our hospital's radiology information system (RIS) between December 2011 and April 2017); the general term "band" was used for a wide search, and only CT scans with LAGB were then included.

Patients' computerized medical records were studied; demographic and clinical data were collected, including age, gender, and time from procedure (when available). Clinical indications for the CT scans were retrieved from referral notes.

CT scans were reviewed in consensus by two radiologists (radiologist 1 with 28 years of experience and radiologist 2 with 2 years of experience) to identify findings suggestive of complications resulting from LAGB.

Findings were compared with referral notes and dichotomized into two groups: the symptomatic group, in which the LAGB complication was thought to cause acute symptoms, and the incidental group, in which complications were incidental. Complication frequency in our cohort was calculated for both groups.

Normal esophageal diameter was defined as less than 35 mm [24].

Small bowel obstruction, when present, was counted as a LAGB complication only when attributed to adhesions in patients with no other surgical history.

Results

One hundred sixty patients who underwent CT after LAGB were found, with an average age of 51 ± 12 years. The male to female ratio was 1:2.33 (48 men, 112 women). Eighty-three (83) findings suggestive of complications were identified in 69/160 patients (43.1%; CI 35.3–51.2%). CT examinations included 99 abdominal scans, 34 chest-abdomen scans, 25 chest scans, and 2 spinal scans. Indications for abdomen or chest-abdomen scan were abdominal pain ($n = 74$), cancer follow-up ($n = 17$), fever or sepsis ($n = 12$), trauma ($n = 8$), jaundice ($n = 4$), abdominal mass identified on ultrasound (n = 4), dysphagia ($n = 2$), and other varied indication ($n = 12$). Indications for chest scans were chest pain ($n = 8$), cough ($n = 6$), dyspnea ($n = 3$), fever ($n = 2$), pleural effusion and mass evaluation ($n = 2$), and other varied indication ($n = 4$). Spinal CT scans were indicated for back pain ($n = 2$). All subjects were more than a year post operation.

The complications encountered in our cohort of 160 patients were esophageal dilatation (47/160, 29.4%) (Fig. 1), pulmonary complications (13/160, 8.2%) including empyema (2/160, 1.3%), consolidation (7/160, 4.4%) and abscess formation (4/160, 2.5%) (Figs. 2 and 3), small bowel obstruction attributed to adhesions (5/160, 3.1%), abdominal abscess (6/160, 3.8%) (Fig. 4), intragastric band erosion (4/160, 2.5%) (Figs. 5 and 6), tube disconnection (4/160, 2.5%)

Table 1 LAGB complications identified by CT

	Symptomatic ($n = 38$)	Incidental ($n = 45$)	Findings/patients ($n = 160$)
Esophageal dilatation	10 (26.3%)	37 (82.2%)	47/160 (29.4%)
Pulmonary (total)	10 (26.3%)	3 (6.7%)	13/160 (8.2%)
Pulmonary abscess	4 (10.5%)		4/160 (2.5%)
Pulmonary consolidation	4 (10.5%)	3 (6.7%)	7/160 (4.4%)
Empyema	2 (5.3%)		2/160 (1.3%)
Abdominal abscess	6 (15.8%)		6/160 (3.8%)
Small bowel obstruction	5 (13.2%)		5/160 (3.12%)
Intragastric band erosion	3 (7.9%)	1 (2.2%)	4/160 (2.5%)
Port site and tube course infection	3 (7.9%)		3/160 (1.9%)
Small gastric pouch bezoar	1 (2.6%)		1/160 (0.6%)
Tube disconnection		4 (8.9%)	4/160 (2.5%)

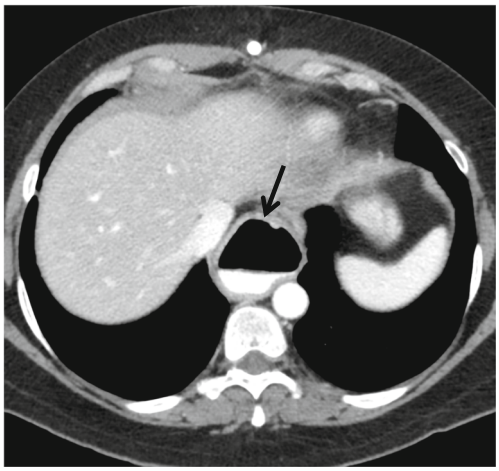

Fig. 1 Distal esophagus dilatation in a 54-year-old woman with lower abdominal pain. Axial CT image shows distal esophagus dilatation up to 5 cm with air fluid level (arrow)

(Fig. 7), port site and tube course infection (3/160, 1.9%) (Fig. 8), and small pouch bezoar (1/60, 0.6%) (Fig. 9).

In all patients with pulmonary findings suggestive of a complication, there was esophageal dilatation; among these patients, retained content in the esophagus was identified in 10/13 (77%) of cases. All pulmonary abscesses were identified either in the posterior segment of the upper lobes or in the superior segment of the lower lobes, common sites for aspiration. Thus, it was assumed that these new pulmonary findings in otherwise healthy patients were due to aspiration.

When CT-identified complications were compared with referral notes, 38/83 (45.8%) were judged to be responsible for the acute symptoms that were the indication for the exam, whereas 45/83 (54.2%) of the complications were incidental.

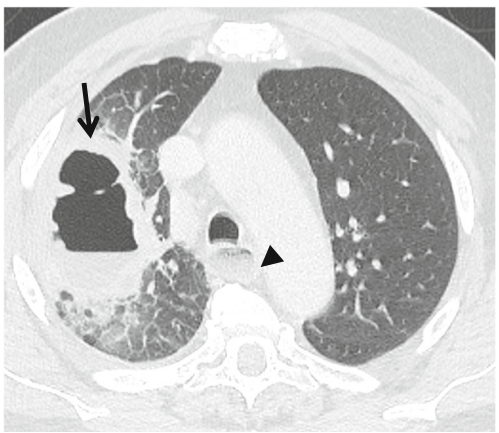

Fig. 2 Pulmonary abscess in a 64-year-old man with a 2-week history of fever and cough, 1 year after LAGB surgery. The patient complained of chronic regurgitation and vomiting. Axial CT image shows a large right upper lobe cavitary mass (arrow) with air fluid level. Dilated esophagus with air fluid level was also noted (arrowhead). The patient recovered after empiric antibiotic treatment. Fourteen months later, the patient had pneumonia recurrence

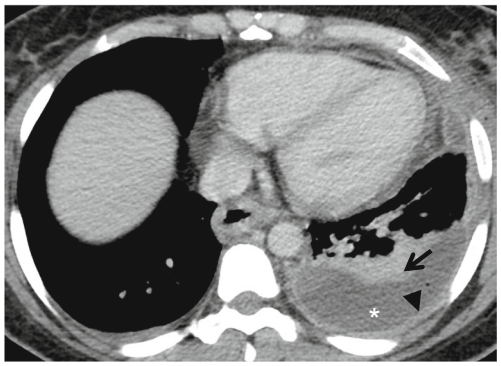

Fig. 3 Empyema in a 39-year-old woman with cough, 1 year after operation. Axial CT image shows left lower lobe atelectasis (arrow), left side pleural effusion (asterix), and parietal pleura enhancement (arrowhead) suspicious for empyema. The patient was treated with antibiotics and chest tube

In the symptomatic findings group, when counting only acute presentations, the complications were pulmonary (10/38, 26.3%) including pulmonary abscesses 4/38, pulmonary consolidation 4/38 and empyema 2/38, esophageal dilatation that were associates with acute pulmonary findings 10/38 (26.3%), abdominal abscess 6/38 (15.8%), small bowel obstruction 5/38 (13.2%), intragastric band erosion 3/38 (7.9%), port site and tube course infection 3/38 (7.9%), and small pouch bezoar 1/38 (2.6%).

In the incidental finding group, the complications were pulmonary consolidation 3/45 (6.7%), esophageal dilatation 37/45 (82.2%), tube disconnection 4/45 (8.9%), and intragastric band erosion 1/45 (2.2%).

When comparing the complication frequency between the two study groups, pulmonary abscesses (four patients) and abdominal abscesses (six patients) were symptomatic in all patients, as well as empyema (two patients), port site infection (three patients), small bowel obstruction (five patients), and obstruction by bezoar (one patient). Intragastric band erosion was symptomatic in three patients and discovered incidentally in one patient; the latter patient underwent spinal CT for back pain which did not identified spinal fracture or discopathy. Pulmonary consolidation was identified in both symptomatic and incidental groups.

Discussion

In accord with predictions based on the literature, we have observed a high frequency of findings suggestive of late complications in our cohort of patient who underwent CT after LAGB (43%). Less than half of the findings were symptomatic (45.8%), and the rest were incidentally identified.

Overall, the most common finding was esophageal dilatation. *Esophageal dilatation* was identified in 29.4% of patients. We used the 35-mm standard cutoff based on the

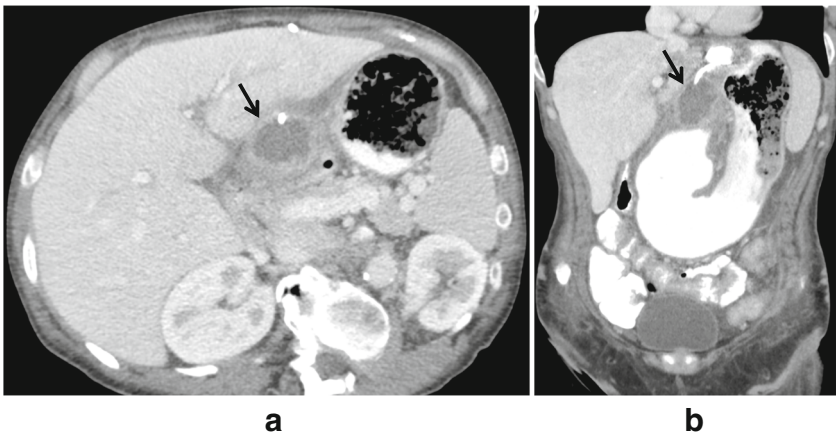

Fig. 4 Abdominal abscess in a 55-year-old woman with periumbilical pain 3 years after LAGB surgery. Axial (**a**) and coronal (**b**) CT images show an abscess in the tube course near the lesser curvature of the stomach (arrow). Band removal and abscess drainage were recommended, yet the patient refused surgical intervention

study of Naef et al. [24] in a barium swallow series. Measurements were made at the distal esophagus due to the perpendicular orientation hence facilitating evaluation in an axial section. This result is congruent with data reported in Naef et al.'s series, indicating that up to 25% of patients have esophageal dilatation after LAGB. Most esophageal dilatations were determined to be an asymptomatic complication when compared with the referral notes. Esophageal dilatation was judged to be symptomatic, for our study purpose, when it was thought to cause acute symptoms. Among patients with esophageal dilatation, 10/47 (21.2%) were acutely symptomatic and presented with acute pulmonary complications (10/47). None of our patients presented with vomiting or reflux as an indication for the examination. A more ominous complication, *intragastric band erosion*, was identified in 2.5% in our series and has been observed in 0.3 to 14% in clinical series [7]. Patients may present with nonspecific complaints, as demonstrated in our series with erosion identified incidentally in a spinal CT indicated for back pain. Radiologists are advised to look for this complication, even in asymptomatic patients as it may lead to abscess formation, peritonitis, and tube course infection [7]. Band erosion can cause an *abdominal infection*, in times manifesting solely with port site infection. Band erosion can cause tube course infection and abdominal abscess. As previously depicted in a pictorial essay by Sonave et al. [7] and shown in our cohort, abdominal infection as a delayed complication of LAGB can occur even in the absence of band erosion; in such case, findings are assumed to be attributed to LAGB by the close proximity to the system components.

Another well-recognized delayed complication is *tube disconnection* which was identified in 2.5% and did not account for any acute symptoms. This complication can result in malfunction of the band and can lead to reversal of weight loss. The disconnect usually happens at the junction of the tube with the port or the band [7]. Radiologists should pay attention to the tube course and seek any disconnection. Contrary to expectations, *gastric band slippage* with the

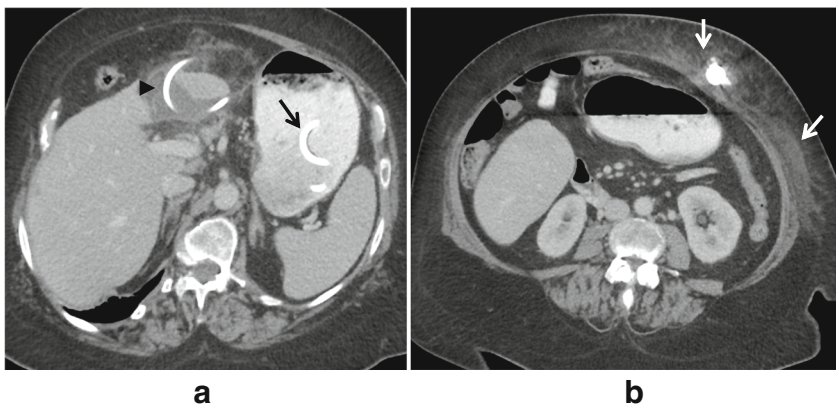

Fig. 5 Complete intragastric band erosion in a 69-year-old woman 20 years after a LAGB surgery. The patient presented with skin erythema at the port site. Axial CT images show **a** intraluminal migration of the band (arrow). Peritoneal fluid collection along the tube course (arrowhead) and **b** subcutaneous fat stranding around the port and left flank (arrows). Surgical debridement and removal of the port were performed and an endoscopic band removal ensued

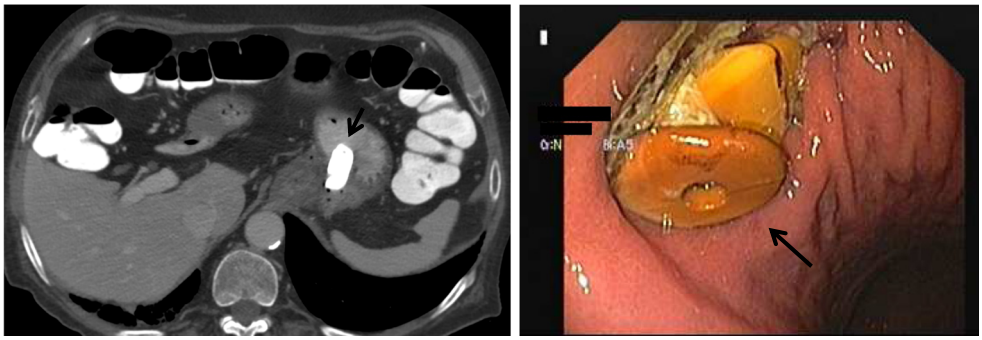

Fig. 6 Partial intragastric band erosion in a 73-year-old man 25 years after a LAGB surgery. The patient presented with syncope and developed sepsis during hospitalization. Axial CT image (**a**) and endoscopic image (**b**) show gastric band partially eroding into the gastric lumen (arrow). A small left subphrenic abscess was also noted (not shown). Endoscopic removal of the band was performed. The abscess disappeared in a follow-up CT scan 1 month later

typical phi angle above 58[°7 was not identified in any of our patients.

Alongside abdominal complication, we have identified *thoracic complications* in 8.2% of patients, including pulmonary abscess (2.5%), empyemas (1.3%), and pulmonary consolidations (4.4%). Thoracic complications after bariatric surgery have only recently been emphasized in the radiologic literature in a pictorial essay by Galgano and Sonave. [23]. Although we did not actively prove aspiration in each of our patients with a swallow study, it is assumed that aspiration was the cause of these new pulmonary findings due to demonstrated esophageal dilatation with retained contents within it, in otherwise healthy patients. Moreover, the location of the pulmonary abscess identified was typical for aspiration. Our results corroborate previous clinical series reporting an increased risk of major respiratory complications in the long-term post-operative period of LAGB [22].

Not all incidentally identified complications were insignificant: in our cohort, 18% (8/45) had clinical importance (one intragastric band erosion, three pulmonary consolidations, and four tube disconnections). Therefore, we advise radiologists to systemically check for complications in every patient who underwent CT after LAGB, even if asymptomatic. A proposed checklist of complications to look for:

☑ Band position - erosion, slippage

☑ Tube course – disconnection or fat stranding

☑ Port site – fat stranding

☑ Chest – consolidation, abscess or empyema

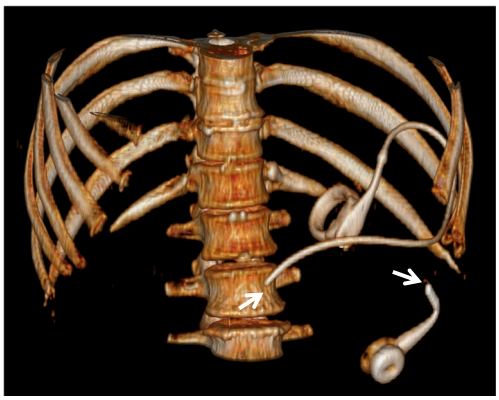

Fig. 7 Tube disconnection in a 47-year-old woman, 16 years after LAGB surgery. Volume-rendered 3D CT reconstruction shows a disconnection at the junction of the tube with the port (arrows)

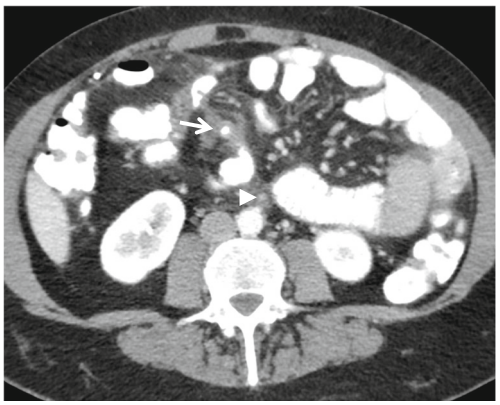

Fig. 8 Infection along the tube course in a 54-year-old woman, 10 years after LAGB surgery. The patient presented with right lower quadrant (RLQ) pain. Axial CT image shows fat stranding and fluid around the tube (arrow). Reactive lymph nodes were identified (arrowhead). The patient was referred for LAGB revision to another bariatric surgery

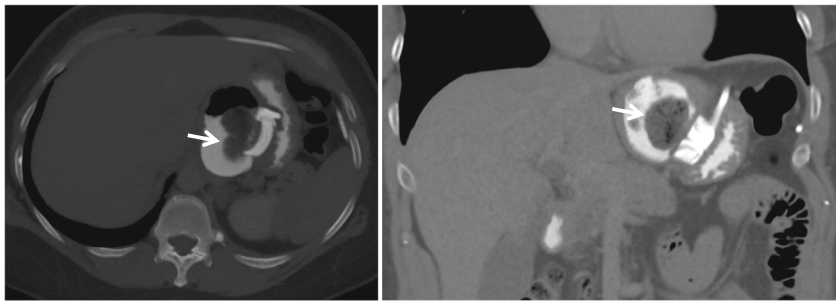

Fig. 9 Small gastric pouch bezoar in in a 47-year-old woman, 16 years post LAGB surgery, with a 4-day history of vomiting after eating a persimmon. Axial maximum intensity projection (MIP) image (**a**) and coronal reconstruction CT image (**b**) show a bezoar at the small gastric pouch (arrow). The patient underwent endoscopy, and a phytobezoar was evacuated

Limitations

Our study has several limitations. This is a retrospective study, and as such is limited to data retrieved from patients' medical records. The patients' symptoms and complaints were extracted from the referral notes without targeted patient interview. We have calculated complication frequency identified by CT in patients with LAGB. This calculation should not be confused with a complication rate in the general post-LAGB population and is investigated in large clinical follow-up studies.

Intraabdominal infections were presumed to be attributed to the LAGB system when close proximity of the findings was highly suspicious of the diagnosis.

Pulmonary complications were attributed to aspirations resulting from dilated esophagus and regurgitation.

In some of the patients, we lacked information about the exact date of the surgery. Yet, all the subjects' complications were late complications (more than a year post operation), explained by the shift towards other bariatric surgeries in recent years.

Given the retrospective nature of this study design, many surgical notes were unavailable; hence, no statistics about band manufacturers was included in our study.

Conclusions

Complications were found in 43% of CT scans of patients who underwent LAGB.

Less than half of the complications were symptomatic, and the rest were incidentally identified. Some incidentally identified complications had significant clinical importance.

Although not the most common, pulmonary complications are not negligible after LAGB.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent This study is a retrospective study. Informed consent statement does not apply.

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