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Original Research Article

PREDICTIVE VALUE OF MDCT INTRAPERITONEAL AIR AND FLUID DISTRIBUTION FOR LOCALISING GASTROINTESTINAL PERFORATIONS

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ABSTRACT

Background: To evaluate the diagnostic accuracy of MDCT in localising the site of gastrointestinal perforation with emphasis on extraluminal gas (EG) and fluid (EF) distribution patterns, correlating imaging findings with intra-operative findings. **Materials and Methods:** Retrospective analysis of 37 patients with suspected GI perforation had MDCT before surgery from January 2023 to December 2025. Analysis focused on EG predominance (supracolic vs infracolic), EF patterns, bowel wall thickening, fat stranding, and air bubble localisation. Diagnostic accuracy, sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated for gas and fluid-based predictors. **Results:** Mean age was 42.8 years (10–84), with marked male preponderance (30:7). Stomach and appendix were the commonest sites (11 each, 29.7%), followed by ileum (6), jejunum (4) and colon (3); two patients had no perforation at surgery. Moderate-or-gross pneumoperitoneum occurred in 81.8% of gastric, 60% of jejuno-ileal and 100% of colonic perforations, but in none of the appendicular cases ($p = 0.009$). On dichotomised analysis, this difference was even stronger (15/21 vs. 3/14; OR 9.17, $p = 0.006$). Free air was supracolic in 90.9% of gastric and infracolic in 100% of appendicular and colonic perforations. Air bubbles next to the bowel were seen in 91.4% overall. **Conclusion:** MDCT accurately localises GI perforation sites using extraluminal gas distribution as the primary anatomical predictor. Supracolic predominance is highly specific for upper GI pathology, while infracolic patterns favour appendicular sources. Combined analysis of EG predominance, EF patterns, and secondary signs provides complementary information for accurate pre-operative localisation and prognostication.

INTRODUCTION

GI tract perforation is a common surgical emergency, with mortality reported as high as 30 to 50% even in well-resourced centres.[1,2] Its presentation is often vague and can mimic other causes of acute abdomen, so imaging plays a central role in getting patients to the right operation quickly.[3] Plain films miss free air in around a third of cases, and ultrasound is limited by bowel gas.[4]

MDCT has largely taken over as the first-line investigation. It is sensitive for even small amounts of pneumoperitoneum, and thin sections with coronal and sagittal reformats often let the radiologist suggest not just that a perforation is present, but roughly where it is.[5,6] Maniatis et al. found that MDCT correctly identified the site of perforation in 86% of 85 surgically proven cases, with clustered air bubbles near the bowel being the strongest single predictor.[7]

It has long been recognised that the amount and location of free air varies with the level of perforation. A perforated peptic ulcer tends to produce a large, supramesocolic pneumoperitoneum, whereas a small-bowel perforation often leaks only a small amount of gas close to the perforation itself.[8,9] Perforated appendicitis is at the other extreme — the appendiceal lumen holds very little gas, so rupture frequently produces minimal or even undetectable pneumoperitoneum.[8] Drakopoulos et al. used CT volumetry in 172 patients and proposed a two-step algorithm, based on the volume of free air and ascites, to localise perforation to the upper, middle or lower GI tract.[10]

Most of this work comes from outside India and often relies on volumetric software that is not available for routine reporting. We do not have much local data correlating a simple visual grading of pneumoperitoneum with surgical findings. We therefore set out to look at how the amount and distribution of free air on MDCT relates to the surgically confirmed site of perforation, and how useful the standard ancillary CT signs are at each site.

MATERIALS AND METHODS

Study design and setting: This was a retrospective observational study in the Department of Radiodiagnosis, PESIMSR, Kuppam, after Institutional Ethics Committee approval. Written informed consent was waived off as it is retrospective study. The study included patients from January 2023 to December 2025.

Patients: We included 37 patients of either sex with suspected GI perforation who underwent MDCT before surgery.

Inclusion criteria

Patients with suspected GI perforation to have undergone both a pre-operative MDCT scan and subsequent surgical exploration.

Exclusion criteria

Patients who managed non-operatively or those who underwent surgery without prior MDCT imaging.

CT technique: Scans were done on a GE revolution aspire MDCT scanner. Acquisition of the abdomen and pelvis CT scan was done following the standard institutional protocol.

Image analysis: Images were analysed and blinded to the operative findings, reviewed each scan together and recorded:

a) extraluminal gas — graded minimal, mild, moderate or gross; its predominant compartment — supracolic or infracolic.
b) free fluid — graded minimal to gross, with predominant compartment.
c) ancillary signs — air bubbles adjacent to the affected bowel, abnormal mural enhancement, wall thickening, fat stranding.

Where the findings allowed a single best guess at the site of perforation.

Reference standard and statistics

Operative findings were the reference standard. CT-predicted sites were compared with these. Data were analysed in SPSS v26. Continuous variables are given as mean (range), categorical variables as n (%). The amount of pneumoperitoneum (moderate/gross vs. minimal/mild) was compared across upper, middle and lower GIT using the chi-square test, and on a dichotomised 2×2 basis using Fisher's exact test. $p < 0.05$ was taken as significant.

RESULTS

Patients

Mean age was 42.8 years (range 10–84), with a strong male preponderance (30 men, 7 women; M:F 4.3:1). Surgery confirmed a perforation in 35 of 37 patients; in two, no perforation was found despite CT features suggesting one, and these two were left out of the site-wise analyses.

Table 1: Demographic profile (n = 37)

Variable	Value
Age (years), mean (range)	42.8 (10–84)
Male, n (%)	30 (81.1)
Female, n (%)	7 (18.9)
Perforation confirmed at surgery	35 (94.6)
No perforation found at surgery	2 (5.4)

Site of perforation: Stomach and appendix were equally common, each making up 11 of 37 cases (29.7%). Ileum accounted for 6 (16.2%), jejunum for 4 (10.8%) and colon for 3 (8.1%). [Table 2]

Table 2: Site of perforation at surgery

Site	n	%
Stomach	11	29.7
Appendix	11	29.7
Ileum	6	16.2
Jejunum	4	10.8
Colon	3	8.1
Not found at surgery	2	5.4
Total	37	100.0

Amount of pneumoperitoneum: Every patient had some pneumoperitoneum on CT. Moderate-or-gross free air was seen in 9/11 gastric (81.8%), 2/4 jejunal (50.0%), 4/6 ileal (66.7%) and 3/3 colonic (100%) perforations. The appendix stood apart — 10 of 11 cases (90.9%) had only minimal free air, the remaining one had mild free air, and none had moderate or gross pneumoperitoneum. [Table 3]

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Table 3: Grade of extraluminal gas by site

Site (n)	Minimal n (%)	Mild n (%)	Moderate n (%)	Gross n (%)
Stomach (11)	0 (0)	2 (18.2)	7 (63.6)	2 (18.2)
Jejunum (4)	1 (25.0)	1 (25.0)	2 (50.0)	0 (0)
Ileum (6)	1 (16.7)	1 (16.7)	4 (66.7)	0 (0)
Appendix (11)	10 (90.9)	1 (9.1)	0 (0)	0 (0)
Colon (3)	0 (0)	0 (0)	2 (66.7)	1 (33.3)
Total (35)*	12 (34.3)	5 (14.3)	15 (42.9)	3 (8.6)

***Excludes the two patients with no perforation at surgery.**

Grouping sites as upper (stomach), middle (jejunum + ileum) and lower (appendix + colon) GIT, moderate-or-gross air was seen in 81.8% of upper, 60.0% of middle and 21.4% of lower GIT perforations — a significant difference (chi-square = 9.41, p = 0.009). Comparing upper+middle against lower as a 2×2 table sharpened this further: 15/21 (71.4%) vs. 3/14 (21.4%), Fisher's exact OR 9.17, p = 0.006. [Table 4]

Table 4: Pneumoperitoneum grade by anatomic level

Tier	Moderate/Gross n (%)	Minimal/Mild n (%)	Total
Upper (stomach)	9 (81.8)	2 (18.2)	11
Middle (jejunum + ileum)	6 (60.0)	4 (40.0)	10
Lower (appendix + colon)	3 (21.4)	11 (78.6)	14
Total	18 (51.4)	17 (48.6)	35

Chi-square (3×2) = 9.41, p = 0.009. Dichotomised (upper+middle vs. lower) — Fisher's exact OR = 9.17, p = 0.006.

Distribution and adjacent air bubbles: The predominant compartment of free air also tracked the site closely. Free air was supracolic-predominant in 90.9% of gastric, 75.0% of jejunal and 66.7% of ileal perforations, but infracolic-predominant in 100% of appendicular and 100% of colonic perforations. [Table 5]

Table 5: Predominant compartment of free air by site

Site (n)	Supracolic n (%)	Infracolic n (%)
Stomach (11)	10 (90.9)	1 (9.1)
Jejunum (4)	3 (75.0)	1 (25.0)
Ileum (6)	4 (66.7)	2 (33.3)
Appendix (11)	0 (0)	11 (100.0)
Colon (3)	0 (0)	3 (100.0)

Air bubbles next to the affected bowel were the most consistent sign across the board — present in 32 of 35 cases (91.4%), and in over 80% of cases at every site, irrespective of how much free air was present overall or where it was concentrated. [Table 6] Free fluid was present in all 35 perforated patients, so it added little for distinguishing sites, though it was supracolic-predominant in most gastric cases (81.8%) and infracolic-predominant in all appendicular cases.

Table 6: Adjacent air bubbles and free fluid by site

Site (n)	Air bubbles adjacent n (%)	Free fluid present n (%)	Fluid supracolic n (%)
Stomach (11)	9 (81.8)	11 (100.0)	9 (81.8)
Jejunum (4)	4 (100.0)	4 (100.0)	2 (50.0)
Ileum (6)	6 (100.0)	6 (100.0)	1 (16.7)
Appendix (11)	10 (90.9)	11 (100.0)	0 (0)
Colon (3)	3 (100.0)	3 (100.0)	1 (33.3)
Total (35)	32 (91.4)	35 (100.0)	13 (37.1)

Extraluminal Fluid Patterns: Extraluminal fluid was present in 37/37 cases (100%). Infracolic predominance was more common (24 cases) than supracolic (13 cases). Site-specific patterns showed: gastroduodenal 9 supracolic/2 infracolic; appendix 11 infracolic/0 supracolic; small bowel variable. Fluid volume and attenuation characteristics correlated with perforation site aetiology. Ancillary signs Fat stranding was almost universal (34/35, 97.1%). Wall thickening was present in 82.9% overall, highest in the colon (100%) and appendix (90.9%). Abnormal mural enhancement was seen in 48.6% overall. A delineated focal defect — the clearest direct sign of the perforation itself — was seen in 81.8% of appendicular cases but in none of the 3 colonic cases, and in only 25–33% of small-bowel perforations. [Table 7]

Table 7: Ancillary findings by site

Site (n)	Abn. enhancement n (%)	Wall thickening n (%)	Fat stranding n (%)	Focal defect n (%)
Stomach (11)	7 (63.6)	9 (81.8)	11 (100.0)	3 (27.3)
Jejunum (4)	1 (25.0)	3 (75.0)	4 (100.0)	1 (25.0)

Ileum (6)	3 (50.0)	4 (66.7)	5 (83.3)	2 (33.3)
Appendix (11)	4 (36.4)	10 (90.9)	11 (100.0)	9 (81.8)
Colon (3)	2 (66.7)	3 (100.0)	3 (100.0)	0 (0)
Total (35)	17 (48.6)	29 (82.9)	34 (97.1)	15 (42.9)

CT accuracy for site: A specific site was suggested on CT in 22 of 37 cases (59.5%), and this matched surgery in 21 (95.5%). The one mismatch was a gastric pre-pyloric perforation read as a left infracolic jejunal perforation. Of the 15 cases without a CT-suggested site, six were appendicular — in these, the right iliac fossa picture (minimal infracolic air, fat stranding, wall thickening, often a visible defect) was typical of appendicitis even though the appendix was not explicitly named as the source.

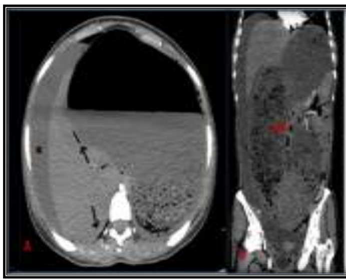

FIG 1 : Case of gastric volvulus with associated pyloric perforation. (A) Contrast-enhanced MDCT demonstrates a moderate volume of EF(*) and EG (↖) surrounding the hepatic margin. (B) Coronal image shows grossly distended and rotated stomach. The orientation is inverted, with the greater curvature on the right side and the lesser curvature on the left side. An abrupt transition is identified at the antropyloric region (↘), consistent with an organo-axial gastric volvulus.

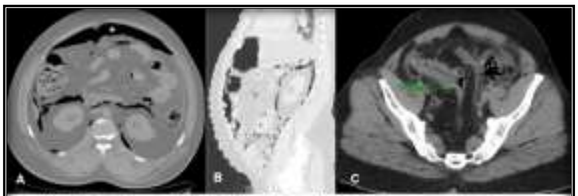

Fig 2 : **MDCT findings in a case of sigmoid colon perforation. (A)** Axial and **(B)** coronal images demonstrate extraluminal collections with a distinct predominance within the inframesocolic compartment and the retroperitoneal space. **(C)** Image demonstrates a focal, mass-like circumferential wall thickening at the rectosigmoid junction, consistent with a primary neoplastic growth.

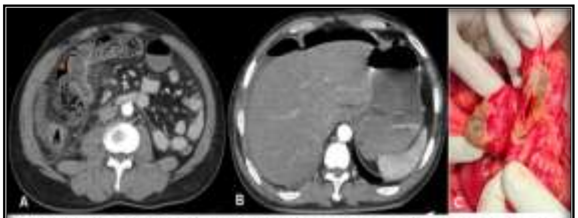

Fig 3 **Case of ileal perforation (A)** Contrast-enhanced MDCT reveals a discrete defect in the small bowel wall (*). The involved loop displays the 'small bowel feces sign' with extrusion of fecal contents, adjacent extraluminal air bubbles, and marked surrounding mesenteric fat stranding. **(B)** Mild to moderate extraluminal gas and fluid are seen predominantly in the perihepatic space. **(C)** Intra-operative photograph showing the isolated loop of the ileum, confirming the exact site of the perforation.

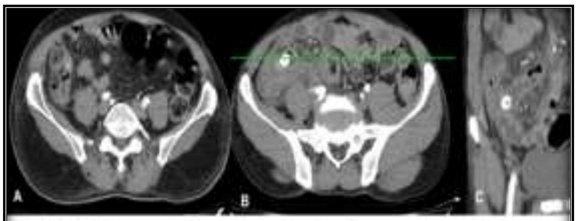

Fig 4 :MDCT findings in a case of appendicular perforation. (A) Image demonstrates an inflamed appendix accompanied by adjacent minimal air foci and a localized minimal fluid collection. **(B)** Axial and **(C)** zoomed coronal images of the same patient reveal an obstructive fecolith within the appendiceal lumen. Associated adjacent minimal air foci and fluid are again noted, confirming the localized site of perforation.

DISCUSSION

Correctly diagnosing the site of GI perforation before the surgery changes how the surgeon plans the operation — open or laparoscopic, and which incision to give. In our 37 patients, both the amount and the compartmental distribution of pneumoperitoneum and free fluid tracked the level of perforation closely. Moderate-or-gross, supracolic air went with gastric perforation; minimal, infracolic air went with appendicular perforation. This fits Kim et al.'s description of gastroduodenal perforation typically producing a large pneumoperitoneum and small-bowel or appendicular perforation often producing free air too small to detect easily.[8]

That none of our 11 appendicular perforations showed more than mild free air makes sense given the appendix's small luminal volume — there simply isn't much gas to escape when it ruptures.[8] What stood out in our data, though, was that the appendix was also the site where a focal defect was most often actually seen on CT (81.8%). So even though the overall pneumoperitoneum looked unimpressive, a clearly visible defect with right iliac fossa fat stranding and wall thickening was, in our experience, a fairly reliable combination for calling an appendicular perforation.

Drakopoulos et al. used CT volumetry in 172 patients and found the largest free-air volumes with stomach and distal colon perforations, and the smallest with small-bowel and proximal colon perforations, with a 185 mL cut-off giving an AUC of 0.64.[10] We used simple visual grading rather than volumetry, but our results point the same way — gastric and colonic perforations mostly had moderate-or-gross air (81.8% and 100%), appendicular perforations did not (0%). Given how strong this association was ($p = 0.006$ on the dichotomised comparison), it seems that even a basic visual grade, without any special software, can meaningfully narrow down where a perforation is likely to be.

Celik et al. found that periportal, perihepatic and perigastric free air predicted gastroduodenal perforation.[11] Our supracolic/infracolic air distribution tells a similar story in a simpler form — 90.9% of gastric perforations were supracolic-predominant, while 100% of both appendicular and colonic perforations were infracolic-predominant. This division needs no special tools and can be read from any axial CT. Choi et al. likewise found the periportal and falciform-ligament air signs more often with gastroduodenal than lower-GIT perforation, which suggest same general idea — where the air sits matters as much as how much there is.[12]

Our overall CT accuracy of 95.5% (21/22) when a site was offered is close to the 86% reported by Maniatis et al,[7] and to Oguro et al.'s figures with 64-slice MDCT.[13] We only offered a specific site in 22 of 37 cases, and six of the remaining 15 were appendiceal.

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Adjacent air bubbles were the most dependable sign — present in over 90% of cases at every site, regardless of the overall amount or distribution of free air. This matches Maniatis et al.'s finding that concentrated air bubbles near the bowel were their strongest predictor of perforation site.[7] Fat stranding (97.1%) and free fluid (100%) were almost always present and so didn't help much in telling sites apart, even though they're important for recognising perforation itself. Pinto et al.'s description of supramesocolic air and a hyperenhancing gastroduodenal wall in perforated peptic ulcer disease matches our gastric perforation, where abnormal enhancement was seen in 63.6%.[14]

A few limitations are- 37 patients is a limited number, and the colonic and jejunal groups are particularly small, so subgroup comparisons should be done cautiously. Grading of free air and fluid was visual rather than volumetric — volumetry, as in Drakopoulos et al., would be more reproducible. This was a single-centre study, so the findings may not generalise elsewhere. Two patients had CT findings suggestive of perforation but none was found at surgery, a reminder that pneumoperitoneum and free fluid are not entirely specific. Finally, we offered a specific site in only 22 of 37 reports — a reporting template that prompts for the supracolic/infracolic distribution, adjacent air bubbles, and the focal-defect sign as standard fields might help us do this more consistently.

CONCLUSION

In our series, both the amount and the compartmental distribution of pneumoperitoneum on MDCT correlated significantly with the site of GI perforation. Moderate-or-gross, supracolic-predominant free air pointed towards a gastric or proximal small-bowel source ($p = 0.006$ on dichotomised analysis), while minimal, infracolic-predominant free air with a visible focal defect and right iliac fossa fat stranding pointed towards the appendix. Adjacent air bubbles were the single most consistent direct sign across all sites, present in over 90% of cases. Taken together, these features let MDCT localise the perforation with 95.5% accuracy when a site was offered, and give the operating surgeon useful information before the patient goes to theatre.

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