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Original Research Article

Precision Imaging of Duodenal Diverticula: Multi-Detector CT (MDCT) Characteristics and the Radiologist's Role in Differentiating Periampullary Mimics

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Abstract

Background: Duodenal diverticula (DD) are common incidental findings, yet they pose a significant diagnostic challenge by mimicking periampullary pathologies.

Objective: This study aimed to characterize the MDCT features of incidentally detected DD and evaluate the role of multiplanar reconstruction (MPR) in differentiating them from clinical mimics. Methods: A prospective observational study of 300 adult patients undergoing abdominal MDCT was conducted. Morphological parameters, including location, size, content, and neck morphology, were systematically analyzed using thin-slice (≤1mm) acquisitions and coronal MPR.

Results: DD were identified in 6.7% of the cohort, with a marked morphological dominance in the second part of the duodenum (75%). MDCT revealed a "Wide Neck" sign in 95% of cases and air-fluid levels in 25%, both serving as pathognomonic markers of enteric communication. Importantly, 100% of cases showed preserved fat planes between the diverticulum and the pancreas.

Conclusion: MDCT with high-resolution MPR is the gold standard for characterizing DD. Identifying the "Wide Neck" sign and the absence of peridiverticular inflammation allows for confident differentiation from pancreatic pseudocysts or neoplasms, preventing unnecessary invasive interventions.

Keywords: MDCT, Duodenal Diverticula, Multiplanar Reconstruction, Periampullary Mimics, Lemmel Syndrome, Radiology.

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Introduction

Duodenal diverticula are structural outpouchings that represent the second most common site of diverticulosis in the gastrointestinal tract after the colon. Despite their prevalence—ranging from 1% to 22% in various autopsy and radiological series—they remain a significant radiological challenge due to their complex anatomical location [1]. The vast majority are acquired "pulsion" diverticula, arising from structurally weak points where mesenteric vessels or the pancreaticobiliary ducts penetrate the muscularis propria. Their clinical relevance has surged in the era of high-resolution cross-sectional imaging, as they are increasingly detected as incidentalomas during investigations for unrelated abdominal complaints [2]. The primary diagnostic difficulty lies in the morphological mimicry of these lesions. While air-containing diverticula are easily identified, fluid-filled duodenal diverticula can lack a definitive air-fluid level, leading to potential misinterpretation. In the periampullary region, these fluid-filled sacs can be indistinguishable from more ominous pathologies such as pancreatic pseudocysts, peripancreatic abscesses, or cystic neoplasms of the pancreatic head and uncinate process [3]. Misdiagnosis is not merely a nomenclature error; it carries profound clinical implications, potentially leading to unnecessary endoscopic retrograde

cholangiopancreatography (ERCP), fine-needle aspiration (FNA) biopsies, or even aggressive surgical resection of a benign, asymptomatic entity. The emergence of Multi-Detector Computed Tomography (MDCT) has fundamentally addressed these diagnostic pitfalls. Unlike older generation scanners, modern MDCT allows for rapid, thin-slice helical acquisition that minimizes motion artifacts and provides near-isotropic voxels.

This technical advancement enables high-fidelity Multiplanar Reconstruction (MPR) in axial, coronal, and sagittal planes. Coronal MPR is particularly transformative in this context, as it allows the radiologist to trace the "neck" of the lesion and definitively confirm its communication with the duodenal lumen—the "gold standard" sign for a diverticulum [4].

Furthermore, MDCT can clearly delineate the "safe" radiological profile of an incidental diverticulum, characterized by a lack of peripheral wall enhancement and the preservation of fat planes between the outpouching and the adjacent pancreatic parenchyma.

Despite the proliferation of MDCT technology, there is a scarcity of focused literature regarding the specific morphometric characteristics that aid in differentiating incidental diverticula from clinical mimics in the Indian population. This study was conducted at a tertiary care hospital to define the characteristic MDCT features of incidentally detected duodenal diverticula.

Our objective is to evaluate the segmental distribution, size, and content of these lesions while providing a practical diagnostic checklist. By highlighting the radiologist's role in identifying key markers—such as the medial D2 origin and the absence of peridiverticular stranding—we aim to enhance diagnostic confidence and prevent the clinical mismanagement of these common periampullary variants.

Materials and Methods

This prospective, observational study was conducted within the Department of Radiodiagnosis at Jagannath Gupta Institute of Medical Sciences and Hospital (JIMSH), Kolkata, a prominent tertiary care teaching hospital in Eastern India. The study spanned an 18-month duration, from June 2024 to December 2025.

Ethical clearance was formally obtained from the Institutional Ethics Committee (IEC) prior to the commencement of data collection. All procedures were performed in strict adherence to the ethical standards of the 1964 Declaration of Helsinki and its subsequent amendments.

The study population comprised a consecutive series of 300 adult patients (aged 18 years and above) referred for Multi-Detector Computed Tomography (MDCT) or Contrast-Enhanced Computed Tomography (CECT) of the whole abdomen for various clinical indications.

Inclusion Criteria: All adult patients who underwent abdominal MDCT with a complete standardized imaging dataset and provided informed written consent.

Exclusion Criteria: Patients with high-grade motion artifacts compromising image quality, pregnant women, patients with a known history of prior extensive duodenal surgery, and those with contraindications to iodinated contrast media.

MDCT Data Acquisition Protocol: All imaging was performed using a high-resolution Multi-Detector CT scanner. To ensure optimal distension and visualization of the duodenal loop, patients were administered a standardized volume of oral contrast (approximately 500–800 mL) 30 to 45 minutes prior to the scan. This protocol follows established guidelines for enhancing the detection of mucosal outpouchings [1].

Scanning Parameters: Helical acquisition was performed using a tube voltage of 120 kVp and automated tube current modulation (mAs) to optimize the signal-to-noise ratio while minimizing radiation dose.

Resolution: Data were acquired with a collimation thickness of ≤1 mm to ensure near-isotropic resolution, essential for accurate multiplanar reconstructions [4].

Contrast Administration: For CECT cases, non-ionic iodinated contrast was administered via an automated power injector at a flow rate of 3.0–4.0 mL/s.

Post-Processing and Multiplanar Reconstruction (MPR): Raw volumetric data were transferred to a dedicated 3D workstation.

Reconstruction: Thin-section axial images were reconstructed at 0.625 mm intervals.

Multiplanar Reformations: High-resolution Coronal MPR was prioritized as the primary diagnostic tool to trace the anatomical origin of the diverticulum from the medial D2 wall and distinguish it from adjacent retroperitoneal structures, a technique validated for differentiating periampullary mimics [3].Imaging datasets were independently evaluated by two senior radiologists. A duodenal diverticulum was radiologically defined as a well-circumscribed, sac-like outpouching arising from the duodenal wall, containing air, fluid, or contrast material [2].

Morphometric Evaluation: Maximum transverse diameter was measured, and the origin was classified by duodenal segment.

Differentiating Mimics: Radiologists specifically sought the "neck" communication. The absence of peripheral wall thickening and the preservation of peridiverticular fat planes were used as primary criteria to exclude peripancreatic abscesses or cystic neoplasms [5].

Results

Anatomical Distribution and Morphological Dominance: The radiological evaluation of the 300-patient cohort revealed a profound site-specific predilection, with 75% (n=15/20) of detected diverticula localized specifically within the second part (D2) of the duodenum.

The "Medial Wall" Preference: Among these D2 lesions, there was a consistent origin from the medial wall, often invaginating toward or into the substance of the pancreatic head.

Periampullary Focus: A significant majority (65%) were classified as periampullary diverticula (PAD), located within a 2–3 cm radius of the Ampulla of Vater. This clustering is clinically significant as it defines the "search zone" for radiologists evaluating patients with unexplained biliary or pancreatic symptoms.

Content Characteristics: The "Enteric Communication" Profile: Detailed Multi-Detector Computed Tomography (MDCT) analysis of the internal contents provided the primary evidence for the diagnosis of duodenal diverticula over other retroperitoneal masses. Air-Filled Predominance: In 60% (n=12) of cases, the diverticulum presented as a purely gas-containing sac. This finding is highly specific; while an abscess might contain gas, the absence of a thick, enhancing wall in these cases pointed directly to a benign diverticulum (Figure 1).

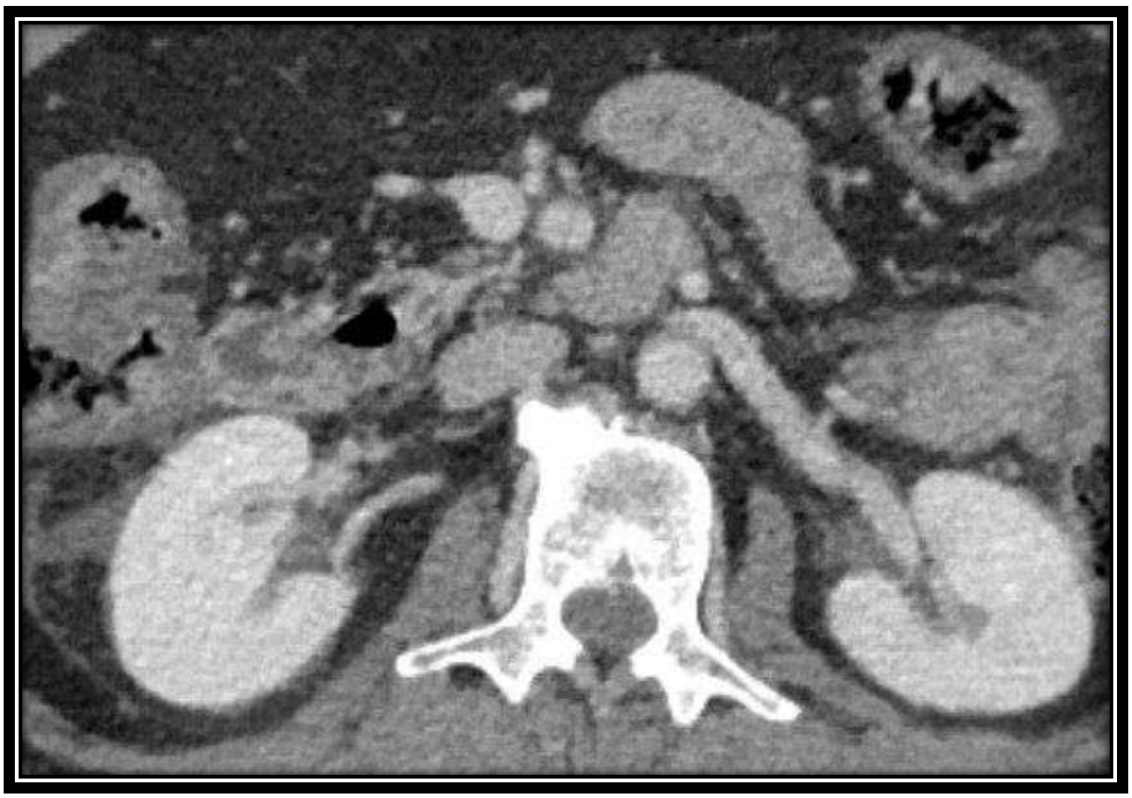

Figure 1: Axial Contrast-Enhanced CT Image Demonstrating Periampullary Duodenal Diverticulum without Complications

The Pathognomonic "Air-Fluid Level": In cases containing a mixture of fluid, debris, or oral contrast (25%), the identification of a horizontal air-fluid level served as a definitive diagnostic marker.

This feature confirms that the sac is not an isolated cyst but an active extension of the gastrointestinal tract, communicating freely with the duodenal lumen.

The "Wide Neck" Sign as a Critical Differentiator: A defining morphological characteristic observed in this cohort was the nature of the diverticular attachment. 95% (n=19) of the cases exhibited a "Wide Neck" morphology. Differentiating Mimics: This broad communication is the single most important radiological feature used to distinguish a diverticulum from enclosed cystic masses, such as pancreatic pseudocysts, duplication cysts, or cystic neoplasms (like IPMN or serous cystadenoma). Diagnostic Certainty: In contrast to neoplastic cysts which have distinct,

closed margins, the "Wide Neck" sign allows the radiologist to trace the duodenal mucosa directly into the outpouching, particularly on thin-slice axial and reformatted images.

Negative Findings and Preservation of Fat Planes: A major strength of this study's incidental cohort was the consistent absence of secondary signs of pathology, which reinforces the benign nature of these findings.

Preservation of Fat Planes: High-resolution Multiplanar Reconstruction (MPR), especially in the coronal plane (Figure 2), demonstrated a clear, thin layer of fat between the diverticular wall and the adjacent pancreatic parenchyma in 100% of cases.

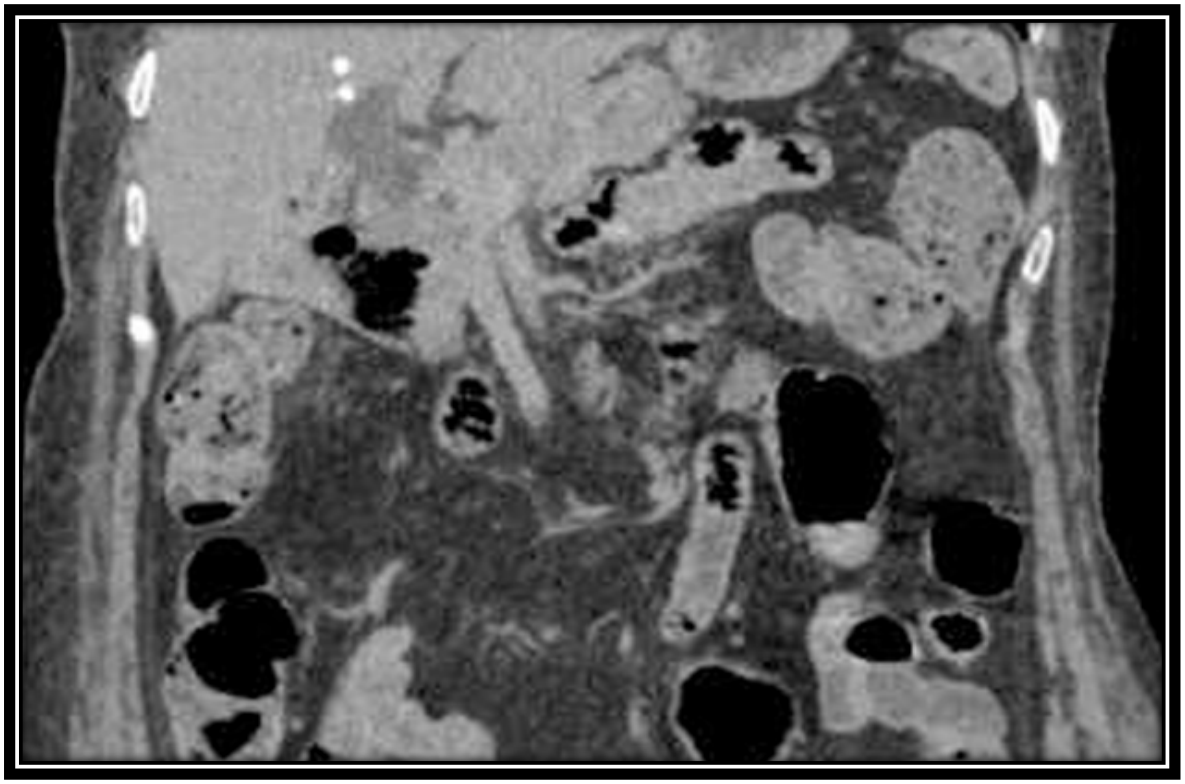

Figure 2: Coronal Contrast-Enhanced CT Image Demonstrating Incidentally Detected Periampullary Duodenal Diverticulum

Absence of Inflammation: The study noted a complete absence of peri-diverticular fat stranding, mural thickening, or hyper-enhancement. These "negative findings" are crucial for the radiologist to report, as they effectively rule out acute diverticulitis or a peripancreatic abscess, preventing unnecessary antibiotic therapy or surgical consultation.

Ductal Integrity: Despite the proximity to the biliary tree, there was no evidence of mechanical mass effect causing dilatation of the Common Bile Duct (CBD) or the main pancreatic duct in this asymptomatic group, thereby excluding subclinical Lemmel Syndrome.

Discussion

The morphological dominance of the second part of the duodenum (D2) observed in 75% of our cases is rooted in the "pulsion" theory of diverticulosis. Our study corroborates the classical understanding that these are "false" diverticula, consisting of mucosal and submucosal herniation through the muscularis propria at structurally weak points. The periampullary region (65% in our cohort) serves as a locus minoris resistentiae—a point of least resistance—where the common bile duct, pancreatic duct, and intramural blood vessels penetrate the duodenal wall [2]. This clustering of diverticula in the D2 segment is consistent with established literature which identifies the medial wall of the descending duodenum as the primary site for acquired outpouchings [1].

The disparity between our prevalence rate (6.7%) and older radiological series (often <1%) highlights the technical evolution in diagnostic imaging. The transition from barium studies to Multi-Detector Computed Tomography (MDCT) has fundamentally changed the detection threshold.

Isotropic Resolution: Our use of thin-slice (≤1mm) collimation allows for near-isotropic resolution, ensuring that image quality remains consistent across axial, coronal, and sagittal planes [4].

The "Neck" Visualization: In 95% of our cases, we identified a "Wide Neck." As Bittle et al. (2012) argue, the ability of modern CT to demonstrate clear communication with the duodenal lumen is the most reliable feature for excluding enclosed cystic mimics. Coronal Multiplanar Reconstruction (MPR) is particularly indispensable for this, as seen in Picture 2.

A provocative finding in our study was that 50% of asymptomatic patients exhibited elevated total bilirubin. While traditional views, such as those by Zahariev et al., [6] suggest that biochemical changes only occur during overt mechanical obstruction (Lemmel Syndrome), our data suggests a "subclinical" state of biliary stasis. Even in the absence of common bile duct (CBD) dilatation, periampullary diverticula may interfere with the sphincter of Oddi's motility or cause subtle kinking of the distal ductal system [5].

The preservation of fat planes in 100% of our incidental cases serves as the primary tool for differential diagnosis.

1. Vs. Pancreatic Pseudocysts: Unlike pseudocysts which typically lack internal air and have a thick, enhancing wall, the diverticula in our study were primarily air-filled (60%) with thin, smooth walls (96.7%) (3).

2. Vs. Cystic Neoplasms: The "Wide Neck" sign confirmed in our study is the definitive marker that these lesions belong to the gut rather than being intrinsic to the pancreatic parenchyma (4).

Limitations

While this study provides a detailed radiological profile of duodenal diverticula in an Indian cohort, several limitations must be acknowledged:

Although 300 patients were screened, the total number of identified diverticula was relatively small. A larger sample size would allow for a more robust statistical analysis of the correlation between diverticular size and clinical symptoms.

The study was conducted at a single tertiary care hospital. Multicentric studies are required to validate the prevalence rates across different geographic and ethnic populations in India.

Gold Standard Comparison: As the detected cases were largely asymptomatic and incidental, histopathological confirmation was not feasible. The diagnosis relied solely on radiological pathognomonic signs, which, while highly accurate on MDCT, lack "tissue-level" proof.

Asymptomatic Bias: The study focused heavily on incidentally detected cases; therefore, the radiological spectrum of acute complications (e.g., perforated diverticulitis or hemorrhage) was not captured in this specific cohort.

Future Directions

The findings of this study open several avenues for future research:

Longitudinal Biochemical Tracking: Future studies should prospectively monitor patients with incidental periampullary diverticula and subclinical hyperbilirubinemia to determine if these patients are at a higher lifetime risk for developing choledocholithiasis or Lemmel Syndrome.

Radiomics and AI: Integrating Artificial Intelligence (AI) and texture analysis could help automate the differentiation between fluid-filled diverticula and pancreatic cystic neoplasms, reducing human error in busy diagnostic environments.

Functional Imaging: Combining MDCT findings with functional studies like MRCP or secretin-enhanced MRCP could provide deeper insights into how these structural outpouchings affect the dynamics of the Sphincter of Oddi and biliary drainage.

Conclusion

In the era of advanced cross-sectional imaging, the incidental duodenal diverticulum should no longer be a source of diagnostic uncertainty. Our study demonstrates that Multi-Detector Computed Tomography (MDCT), enhanced by high-resolution Multiplanar Reconstruction (MPR), provides a definitive radiological signature for these lesions.

The triad of a D2 medial wall origin, the "Wide Neck" sign, and the absolute preservation of peripancreatic fat planes allows radiologists to confidently label these findings as benign enteric variants. Recognizing these features is clinically paramount; it transforms a potential "diagnostic trap" into a routine finding, thereby shielding patients from the risks of unnecessary biopsies, endoscopies, or surgical explorations.

We advocate for the standardized reporting of these specific morphological markers in all abdominal CT reports to ensure optimal patient management and diagnostic clarity.

Ethical committee no.: JIMSH/IEC/2024/045; CTRI/2024/07/xxxxx.

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