

Diagnostic Accuracy of Physical Examination versus Dynamic Ultrasonography in Evaluating Ventral Hernias: A Prospective Open-label Study

MUKESH PANT¹, ROHIT SINGH², SHABI AHMAD³, DEV KUMAR YADAV⁴, VIRENDRA SINGH⁵



ABSTRACT

Introduction: An abdominal hernia occurs when abdominal contents protrude through a weakness in the abdominal wall. Ventral and lumbar hernias are the most common types. Factors such as anatomical weaknesses, trauma and obesity can contribute to herniation. Diagnosis typically involves physical examinations, ultrasonography, Computed Tomography (CT) scans (the gold standard), Magnetic Resonance Imaging (MRI) and laparoscopy.

Aim: To compare the diagnostic accuracy of physical examinations and dynamic ultrasonography in detecting ventral hernias, focusing on sensitivity, specificity and predictive values.

Materials and Methods: This prospective open-label study was conducted in the Department of Surgery in collaboration with the Department of Radiodiagnosis at Swaroop Rani Nehru Hospital in Prayagraj, Uttar Pradesh, India affiliated with Moti Lal Nehru Medical College, Prayagraj, from September 2019 to September 2020. It involved participants aged 16 years and older who presented with abdominal swelling and were scheduled for hernia repair. The intraoperative findings,

considered the gold standard, were compared with the results of clinical examinations and dynamic ultrasonography during surgery. The sensitivity, specificity and predictive values for the surgeon's physical examination and dynamic ultrasonography were calculated.

Results: This study involved 60 patients aged 16 to 65 years, with 31 patients (52%) in the 16 to 40 age range. There were slightly more females 33 (55%) than males 27 (45%). Medical histories indicated that 20 patients (33.33%) were smokers, 11 had diabetes (18.33%), two had Chronic Obstructive Pulmonary Disease (COPD) (3.33%), five had infections (8.33%) and five had anaemia (8.33%), while 17 patients (28.33%) reported no co-morbidities. The main symptoms were pain in 38 patients (63.33%) and swelling in 22 patients (36.66%). Physical examinations found 47 hernia-positive cases and 13 negative ones; dynamic ultrasonography confirmed 49 positives. Surgical findings revealed that 52 patients had a hernia, while eight were diagnosed with other conditions like lipoma and muscular weakness.

Conclusion: This study demonstrated that ultrasound scans are practical tools for diagnosing unclear ventral hernias.

Keywords: Abdominal swelling, Ultrasound scans, European hernia society

INTRODUCTION

An abdominal hernia is the protrusion of abdominal cavity contents through a weakness in the abdominal wall. A ventral hernia occurs in the anterior abdominal wall, excluding inguinal and femoral hernias, while lumbar hernias are included despite their dorsolateral location [1]. Causes of abdominal wall herniation include: 1) Anatomical factors: Natural weaknesses in the abdominal wall, such as the lumbar triangle; 2) Hormonal factors: Factors like calcitonin gene-related peptides that influence hernia formation and laxity of pelvic ligaments during pregnancy; 3) Trauma: Sharp injuries that create defects in the abdominal wall; 4) Other contributing factors: Postoperative infections, poor surgical techniques, smoking and conditions such as diabetes, obesity and altered collagen metabolism [2]. Incisional hernias occur in 10-23% of patients after abdominal surgery, especially following emergencies [3].

Diagnostic modalities for hernias include: 1) Physical examination: Involves inspection, palpation (assessing the size and content of the hernial sac), percussion and auscultation to check for lumps, bulges and bowel sounds; 2) Ultrasonography: Useful for assessing both reducible and irreducible hernias to evaluate hernial content and defect characteristics; 3) CT: The gold standard for hernia diagnosis, providing detailed information on muscle defects and hernial contents; 4) Contrast Barium Radiology: Using contrast to visualise the peritoneum is effective when CT isn't available; 5) MRI:

Helpful in distinguishing between occult hernias and orthopaedic injuries; 6) Laparoscopy: Assesses the feasibility of laparoscopic repair by examining adhesions [4,5].

Physical examination remains a primary diagnostic tool for ventral hernias despite its limitations, particularly in detecting smaller hernias or in obese patients. Studies indicate that physical examination may miss up to 31% of ventral hernias, which imaging techniques can identify [6]. The accuracy of the clinical information provided to radiologists impacts the diagnosis of abdominal wall hernias in up to 25% of cases [7]. According to Young J et al., out of 200 patients studied, 144 reported pain without any palpable hernia or mass on physical examination [8]. Of these 144 patients, 21 were found to have a hernia identified through ultrasound examination and were subsequently referred for surgery. The remaining 108 patients with negative ultrasound results were treated conservatively with rest, heat and anti-inflammatory medications, with most experiencing excellent results. Among the 56 patients who presented with a mass, regardless of pain, 22 had hernias identified through ultrasound. In the other 34 cases, the cause of the mass was not a hernia. This study compares physical examinations with dynamic ultrasonography to evaluate ventral hernias, aiming to calculate the sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of both diagnostic methods.

MATERIALS AND METHODS

This prospective open-label study was conducted in the Department of Surgery at Swaroop Rani Nehru Hospital, Prayagraj, Uttar Pradesh, India from September 2019 to September 2020. The ethical committee approved the study (Ethics Committee Registration No. ECR/922/Inst/UP/2017) and informed consent was obtained from all patients or their guardians.

Inclusion criteria: Patients aged 16 years and older who presented with abdominal swelling and were scheduled for ventral hernia repair surgery, both elective and emergency cases were included in the study.

Exclusion criteria: Patients younger than 16 years, those with active infections, those with abdominal wall fistulas or stomas and those with inguinal or femoral hernias were excluded from the study.

Clinical examinations were performed upon admission, followed by dynamic ultrasonography before surgery. The decision to proceed with surgery was based on the surgeon's clinical judgment, which considered clinical, laboratory and radiological findings. During the surgery, intraoperative findings were compared to those obtained from the initial clinical examination and dynamic ultrasonography. The clinical assessment of the abdomen includes inspection, palpation, percussion and auscultation [Table/Fig-1-3].



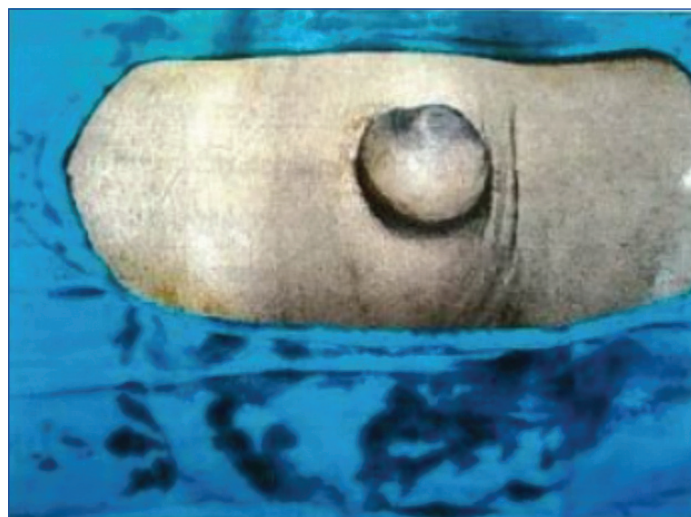
[Table/Fig-1]: Incisional (supraumbilical) hernia.



[Table/Fig-2]: Umbilical hernia.

Radiological investigation: Dynamic ultrasonography [9] was performed using a 12 MHz linear probe, with alternative options based on patient-specific factors available. Patients were scanned in a lying position and a Valsalva manoeuvre or cough impulse was performed in all cases. The assessment focused on measuring

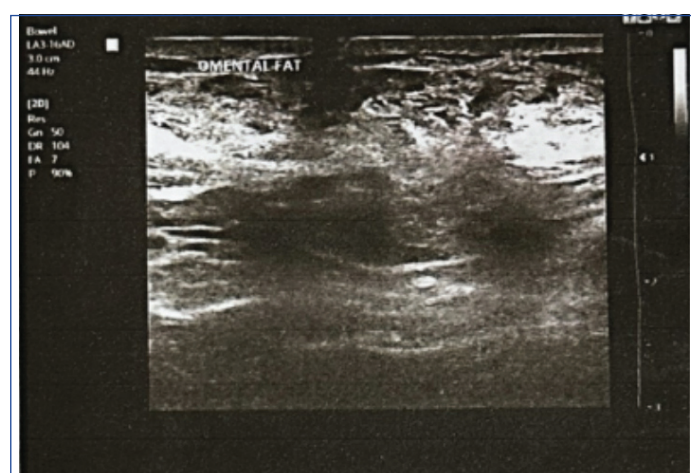
defect size and evaluating sac contents, including fluid [10]. A colour and power Doppler study was also undertaken to rule out bowel ischaemia; other relevant findings were noted [Table/Fig-4,5] [11].



[Table/Fig-3]: Strangulated umbilical hernia.



[Table/Fig-4]: Dynamic ultrasonography showing a defect in supraumbilical region.

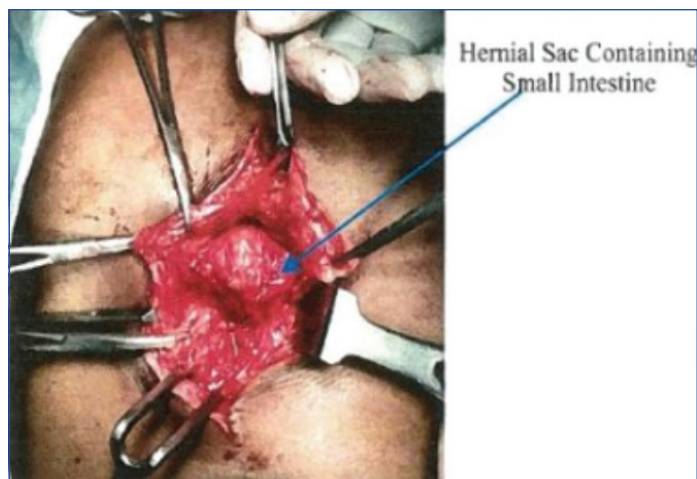


[Table/Fig-5]: Hernia sac containing omental fat in dynamic ultrasonography.

Intraoperative findings: The intraoperative findings (considered the gold standard) were compared with the results of clinical examinations and dynamic ultrasonography during surgery. The sensitivity, specificity and predictive values for the surgeon's physical examination and dynamic ultrasonography were calculated [Table/Fig-6].

STATISTICAL ANALYSIS

The data were entered into the software SPSS 23.0 and appropriate statistical tests were used. Sensitivity, specificity, PPVs and NPVs were calculated using intraoperative findings as the gold standard.



[Table/Fig-6]: Hernial sac containing small intestine.

McNemar's chi-square test was applied to assess statistical significance.

RESULTS

Most participants (51.67%) were in the 16-40 years age range, with a slight female predominance (55% female and 45% male). During the surgeon's physical examination, 47 patients were identified as

positive for a hernia, while 13 were determined to have no hernia. The results from dynamic ultrasonography indicated that 49 patients tested positive for a hernia, while 11 tested negative. Regarding surgical findings, which are considered the gold standard, 52 patients were confirmed to have a hernia, while eight patients were found to have another condition [Table/Fig-7]. Among the eight patients who were hernia-negative during surgery, the diagnosis included three cases of lipoma, three cases of focal muscular weakness in the abdominal wall and two cases of focal hypertrophy of the rectus muscle.

Present study used the European Hernia Society classification [12] for ventral hernias to locate the site of the ventral hernia. Out of 60 patients, five had M1 (subxiphoid), 16 had M2 (epigastric), 13 had M3 (umbilical) and eight had M4 (infraumbilical) types of ventral hernias. Seven patients had sizeable ventral hernia defects: a single patient had M1+M2, four patients had M2+M3, one patient had M3+M4 and one patient had an M4+M5 type of ventral hernia. Eleven patients didn't have any visible defect on the anterior abdominal wall [Table/Fig-8].

When comparing the surgeon's physical examination findings with intraoperative findings, we found 44 true positives, three false positives, five true negatives and eight false negatives for ventral hernia patients (p -value=0.002601; McNemar's chi-square test=

	Variables	Number of patients (%)
Age-wise distribution (years)	16-40	31 (51.67)
	41-65	29 (48.33)
Gender-wise distribution	Male	27 (45)
	Female	33 (55)
BMI (kg/m ²)	<25	38 (63.33)
	>25	22 (36.67)
Co-morbidity	Smoking	20 (33.33)
	Diabetes mellitus	11 (18.33)
	COPD	02 (03.33)
	Infection	05 (08.33)
	Anaemia	05 (08.33)
	None	17 (28.33)
Symptom at presentation	Swelling	38 (63.33)
	Pain	22 (36.67)
H/O Recurrence	Present	13 (21.67)
	Absent	47 (78.33)
Duration of symptoms (years)	<2	36 (60)
	2-5	15 (25)
	>5	09 (15)
Number of defects	Single	40 (67)
	> or = 2 defect	09 (15)
	No defect	11 (18)
Finding of surgeon's physical examination	Hernia present	47 (78.33)
	Hernia absent	13 (21.67)
Finding of dynamic ultrasonography	Hernia present	49 (81.67)
	Hernia absent	11 (18.33)
Intraoperative finding	Hernia present	52 (86.67)
	Hernia absent	08 (13.33)

[Table/Fig-7]: Patients' baseline characteristics.

Site	M1	M2	M3	M4	M1+M2	M2+M3	M3+M4	M4+M5	No hernia
No. of patients	05	16	13	08	01	04	01	01	11
Percentage	8.33	26.67	21.67	13.33	1.67	6.67	1.67	1.67	18.33

[Table/Fig-8]: Sites of ventral hernia.

9.0684) [Table/Fig-9]. When comparing dynamic ultrasonography findings with intraoperative findings, we found 47 true positives, two false positives, six true negatives and five false negatives for ventral hernia patients (p-value <0.00001; McNemar's chi-square test=19.7973) [Table/Fig-10].

Procedure	Intraoperative funding			p-value
Surgeon physical examination	Hernia present	Hernia absent	Total case	
Hernia present	44	03	47	The p-value= 0.002601; McNemar's chi-square test= 9.0684
Hernia absent	08	05	13	
Total case	52	08	60	

[Table/Fig-9]: Comparison of intraoperative findings with surgeons' physical examination results.

Procedure	Intraoperative funding			p-value
Dynamic ultrasonography	Hernia present	Hernia absent	Total case	
Hernia present	47	02	49	The p-value <0.00001; McNemar's chi-square test 19.7973
Hernia absent	05	06	11	
Total case	52	08	60	

[Table/Fig-10]: Comparison of intraoperative findings with dynamic ultrasonography.

In this study, the sensitivity of the surgeon's physical examination was 85%, the NPV was 39%. In contrast, the sensitivity of dynamic ultrasonography was 90% [Table/Fig-11]. No statistical test was performed to compare the surgeon's physical examination with dynamic ultrasonography, as no negative cases existed.

	Parameter	Estimate	Lower-Upper 95% CIs
Surgeon physical examination	Sensitivity	85%	71.92%-93.12%
	Specificity	63%	24.49%-91.48%
	Positive predictive value	94%	85.61%-97.31%
	Negative Predictive Value (NPV)	39%	21.36%-58.98%
Dynamic ultrasonography	Sensitivity	90%	78.97%-96.80%
	Specificity	75%	34.91%-96.81%
	Positive Predictive Value	96%	87.58%-98.74%
	Negative Predictive Value (NPV)	55%	32.26%-75.15%

[Table/Fig-11]: Statistical analysis (surgeon's physical examination & dynamic ultrasonography).

DISCUSSION

Ultrasound is often considered the preferred method for diagnosing ambiguous hernias at many medical centres worldwide [13]. Its effectiveness, especially in diagnosing ventral hernias, is particularly noteworthy compared to a surgeon's physical examination, which is the gold standard. Ahmed Alenazi A et al., indicated that the peak incidence of hernias occurs between the ages of 18 and 50 [14]. The prevalence of hernias was notably higher in females, with rates of 63.4% compared to 36.6% in males [14].

In a retrospective study by Jayaram PR et al., researchers evaluated the effectiveness of dynamic ultrasonography in diagnosing ventral hernias among 348 participants (198 females and 150 males) with an average age of 53.4 years [15]. The results showed that 101 participants (29.0%) were positive for hernias, while 190 (54.3%) tested negative and 57 (16.3%) had other findings, like seromas or lipomas. Out of the total, 54 patients (15.5%) underwent surgery, including five with negative ultrasound results. In the surgical group, there were 45 true positives, four true negatives, four false negatives and one false positive, yielding a sensitivity of 91.8% and a PPV of 97.8%. Overall, the study reported a sensitivity of 91.8% and a specificity of 80.0%.

In present study, dynamic ultrasonography demonstrated a sensitivity of 90% and a PPV of 96%, surpassing the surgeon's sensitivity of 85% and PPV of 94%. Nevertheless, the study yielded excellent results, indicating that these outcomes could be easily replicated in other centres with a similar set-up.

Limitation(s)

Since ultrasound is operator-dependent, the varying skill levels of the surgeons involved sometimes resulted in physical examinations failing to identify reducible hernias.

CONCLUSION(S)

Dynamic ultrasound scanning is an effective tool for diagnosing unclear ventral hernias and can enhance clinical management, leading to more efficient and cost-effective treatment.

Author contributions: M.P. contributed to the intellectual content's concept, design and definition. Additionally, they conducted literature searches, acquired data, performed data and statistical analysis, prepared the manuscript and reviewed it. R.S. and S.A. were involved in the conceptual design, intellectual content definition, literature searches, clinical studies and data acquisition. D.K.Y. and V.S. focused on data analysis, statistical analysis, manuscript preparation, editing and review and also helped define the intellectual content.

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PARTICULARS OF CONTRIBUTORS:

1. Assistant Professor, Department of Radiodiagnosis, Moti Lal Nehru Medical College, Prayagraj, Uttar Pradesh, India.
2. Junior Resident, Department of Surgery, Moti Lal Nehru Medical College, Prayagraj, Uttar Pradesh, India.
3. Professor, Department of Surgery, Moti Lal Nehru Medical College, Prayagraj, Uttar Pradesh, India.
4. Assistant Professor, Department of Radiation Oncology, Moti Lal Nehru Medical College, Prayagraj, Uttar Pradesh, India.
5. Professor, Department of Radiation Oncology, Moti Lal Nehru Medical College, Prayagraj, Uttar Pradesh, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:

Dr. Dev Kumar Yadav,
126/180, Darbhanga Colony (Infront of Navdurga Apartment), George Town,
Prayagraj, Uttar Pradesh, India.
E-mail: devkumar108@gmail.com

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