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FULL PAPER

Evaluation of dynamic ultrasound scanning in the diagnosis of equivocal ventral hernias with surgical comparison

PREM RUBEN JAYARAM, MB ChB, FATIMA DA PEREIRA, MB B Chir, BSc and JAMES A BARRETT, MBBS

Radiology Department, West Suffolk Hospital, Bury Saint Edmunds, UK

Address correspondence to: Dr Prem Ruben Jayaram
E-mail: premruben@yahoo.com

Objectives: This study aims to compare ultrasonography for ventral hernias with surgical findings and establish its accuracy in equivocal cases. Comparison is also made against groin hernia ultrasound scanning, which has a positive predictive value ranging from 71–100%.

Methods: A retrospective review of all patients who underwent an ultrasound scan between June 2011 and June 2015 was performed. The word “hernia” in the referral information was the sole inclusion criterion. Patients who were found to have a clinically evident ventral hernia, unrelated hernia in a separate location or had a known hernia were excluded. Thus, only patients with a clinically suspected ventral hernia and equivocal clinical assessment were included. These patients were followed up for at least 12 months and subsequent operation notes, if any, were also analysed.

Results: 348 scans were included (F = 198, M = 150, F:M ratio = 1.32:1). The mean age was 53.4 years (range = 16–97 years). 101 scans were positive for hernias (29.0%), 190 were negative (54.3%), and 57 had other findings (e.g. seroma, lipoma; 16.3%). 54 patients were taken to surgery (15.5%), including 5 who were found to be negative on ultrasound. Of these, 45 were true-positives, 4 true-negatives, 4 false-negatives, and 1 false-positive, giving a sensitivity of 91.8% and positive predictive value of 97.8%.

Conclusion: This study confirms that ultrasound scans are effective in the diagnosis of equivocal ventral hernias.

Advances in knowledge: The accuracy of ultrasound scanning specifically for ventral hernias is quantified, and are comparable to that of groin hernias.

INTRODUCTION

Ventral hernias are abnormal protrusions of tissues through a defects in the anterior abdominal wall. These are a common problem in any hospital with a surgical practice. There are different types of hernias, including spigelian, epigastric, umbilical, paraumbilical and incisional. They may contain fat or bowel, be reducible or non-reducible. Occasionally, they may incarcerate or strangulate, resulting in bowel obstruction and perhaps ischaemia or infarction.

A recent study documented a three-fold increase in the total number of hernia repair operations performed from the mid-1980s to mid-2000s. While groin hernias were the most commonly operated on by a large margin, there was a disproportionately higher increase in the number of operations for ventral hernias, which increased by more than five-fold.¹ Incisional hernia rates have doubled in the last 30 years from 8% in 1980 to 16% in 2012.² With better surgical

technique, the treatment for these hernias has improved such that more operations are now viable and successful. Similarly, the advent and rapid uptake of laparoscopic surgery has likely heralded an increase in small incisional hernias.³ It is probable that the number of equivocal cases has risen, requiring better tools for diagnosis.

Dynamic ultrasound scanning has long held a place in the diagnosis of these hernias. It is frequently used as a first-line investigation in equivocal cases, especially when the hernia is small and not clinically evident. It is considered safe, quick, cheap, and involves no ionising radiation. However, it is operator-dependent.³

Despite the widely held belief that ultrasound is an effective and accurate tool, there are very few studies proving its effectiveness specifically with regard to ventral hernias. This study will attempt to compare dynamic ultrasound scanning against surgical findings to determine its accuracy.

METHODS AND MATERIALS

A retrospective review was performed of all patients who underwent an abdominal ultrasound scan between June 2011 and June 2015 inclusive. Referral information, ultrasound scan examination details and report were obtained. The reports were analysed to determine the type of hernia present. However, patients were followed up for at least 12 months following their scan by monitoring the hospital information system for further relevant clinic attendances or surgeries. If they underwent an operation for hernia repair, these notes were also gathered.

Ultrasound referrals with the word “hernia” in the given clinical referral information were identified in the radiological information system (RIS). Patients had to have had a prior clinical assessment and have equivocal findings to be included. Those who had a clinically evident hernia were managed conservatively or taken to theatre if appropriate, and were excluded from this study. Paediatric patients (under 16 years of age), or patients who had an unrelated and/or known hernia were excluded at this hospital. Paediatric patients were excluded on the basis that this hospital does not have a dedicated paediatric radiologist. Any paediatric cases that arose were transferred to an affiliated teaching hospital. An unrelated hernia was defined as any hernia outside the anterior abdominal wall, including groin hernias. If incidental hernias were discovered when scanning for other pathologies, these patients were also excluded, on the basis that this was not their primary presenting complaint, and were unlikely to undergo a hernia repair operation.

A Siemens ACUSON S2000 ultrasound machine was used for all scans. Three probes were available to practitioners, namely the 14–5 MHz linear, 9–4 MHz linear and 6–1 MHz curvilinear probes. The 9–4 MHz probe was the most commonly used, but the others were available according to personal preferences or patient factors such as body habitus. Patients were scanned lying down, but a Valsalva manoeuvre or cough impulse was elicited in all cases.

Scans were performed by 9 consultant radiologists, one experienced sonographer who was considered to have equal skill and experience to the consultant radiologists, and 14 registrars in training who were rotating through the department at different times over the study period. All scans performed by registrars were under direct consultant supervision.

Any saved ultrasound images were reviewed to assess the size of the hernia sac and neck. The maximum length and depth of the hernia sac in a single image, and the maximum width of the hernia neck in the same or separate image, as measured across the narrowest point where opposing abdominal walls were clearly identified, was recorded. A hernia sac width and volumetric analysis were not carried out as several patients only ultrasound images recorded in one plane.

Alongside the RIS system, the Picture Archiving and Communication System (PACS) and hospital patient database was used to collect these data, which were then analysed.

Figure 1. Flowchart of patients and results.

Ethical approval was obtained from the local hospital ethics committee for this study.

RESULTS

348 scans were included in the study (M = 150, F = 198, F:M ratio 1.32:1). The mean age was 53.4 years (range 16–97). 101 scans were positive for hernias (29.0%), 190 were negative (54.6%). 57 patients had other findings (16.3%), including one which was indeterminate.

54 patients were operated on (15.5%), including 5 who did not have a hernia on ultrasound (1.4%) and the patient with the indeterminate finding (also classified as not having a hernia). Of these patients, 45 were true-positives (83.3%), 4 true-negatives (7.4%), 1 false-positive (1.9%) and 4 false-negatives (7.4%). Figure 1 illustrates these findings. The indeterminate ultrasound finding was discovered to be an endometrioma upon surgical biopsy and subsequent histological examination, and was classified as a true-negative. The other true-negative surgical findings were 2 lipomas and a normal abdomen, as correctly identified on ultrasound scanning. All operations were undertaken by a consultant surgeon or registrar under the supervision of one.

Of the scans which were positive for hernias, 10 were incisional (secondary) hernias (9.9%). Of these, seven were operated on and were true-positives.

These figures give an overall sensitivity of 91.8%, specificity of 80.0%, and positive predictive value of 97.8%. If only primary (non-incisional) hernias are included, a sensitivity of 90.5% and a positive predictive value of 97.4% is achieved. The specificity remains unchanged at 80.0%. Table 1 provides a classification of the types of hernias and other findings. Figure 2a,b,c illustrate examples of abdominal wall hernias.

Saved ultrasound images were available for 83 patients (82.2%), for whom hernia neck and sac sizes were successfully obtained. These were available for 9 out of 10 of incisional hernias. Table 2 illustrates these results. The average dimensions remain the same (neck = 10.2 mm; length = 25.1 mm; depth = 10.6 mm) if the incisional hernias are removed from the total figures. There is no

Table 1. Classification of the types of hernias and other findings

Classification		Number
Hernias	Para-umbilical	54
	Epigastric	19
	Incisional	10
	Umbilical	9
	Spigelian	9
	Subtotal	101
Other findings	Lipoma	34
	Collection/seroma	13
	Haematoma	9
	Unknown	1
	Subtotal	57

significant difference between the dimensions of the primary and secondary groups (t -test, $p > 0.05$).

Registrars-in-training performed 21 scans (6.0%), and were not responsible for any of the false results, positive or negative. Any positive finding by a registrar was confirmed by a consultant radiologist. The sonographer performed 11 scans (3.2%) and consultants performed the remaining 316 scans (90.8%). The most frequent scanner performed 83 scans (23.9%), whereas the two least frequent consultant scanners performed 10 scans each (2.9% each).

Three practitioners were responsible for all five false results. Of these five false results, three were false-negatives, in whom the scans were performed by two of the consultants with relatively

Figure 2. (a) Spigelian hernia in a male patient at rest. Dotted line shows the width of the defect in the abdominal wall. Arrowheads bound the area occupied by the hernia sac. (b) Spigelian hernia in a male patient during Valsalva manoeuvre. Dotted line shows the increased width of the defect in the abdominal wall. Arrowheads bound the area occupied by the hernia sac. Solid lines illustrate how the length and depth were measured. (c) Para-umbilical hernia containing fat and bowel. Dotted line shows the width of the defect in the abdominal wall. Arrowheads bound the area occupied by the hernia sac.

Table 2. Hernia neck and sac dimensions. All measurements are in millimetres

		Neck	Length	Depth
Primary	Range	5–16	6–52	3–30
	Average	10.2	25.1	10.6
Secondary (incisional)	Range	2–33	10–34	6–15
	Average	10.1	25.6	10.4

low scanning frequency (16 and 17 scans in the study period, respectively). For the remaining two false results, these scans were performed by the second most prolific practitioner (71 scans). No reasons were recorded for these results but they are not statistically significant (χ^2 test, $p > 0.05$).

DISCUSSION

Ultrasound is the modality of choice for diagnosing equivocal hernias in many centres worldwide. Despite this widespread use, there is no quantification of its effectiveness in the diagnosis of ventral hernias, especially when compared to surgery, which is considered the gold standard. Such a quantification, as provided in this study, would provide firm justification for its continued application as a first-line investigation. Only equivocal hernias were included in this study as patients with a clinically evident hernia are operated on without additional investigations.

The authors acknowledge several limitations of this study. Despite including several years of data, the cohort of patients who were taken to theatre remains small at 54. No patients were admitted, re-admitted, or re-investigated due to complications such as pain, strangulation or ischaemia from a hernia that was not diagnosed, or “missed”. Future studies should seek to expand this cohort further. Also, patients were followed up for a relatively short period of 12 months, and could have subsequently been operated on, which may influence the data provided.

Information about patients who had a previous surgery, especially from another centre, was not easily obtainable. This would comprise a significant proportion of patients who had non-incisional hernias as this hospital is a district general hospital in relatively close proximity to a much larger teaching hospital. Therefore, the number of incisional hernias are likely to be underrepresented in this study, and other types of hernias similarly overrepresented. The hernia dimensions recorded in Table 2 provide an understanding of what is considered an equivocal hernia size. It can be appreciated that even the largest hernia in this study (52 mm in length) can be difficult to palpate in an obese patient. Notably, incisional hernias included in this study have similar dimensions to the primary hernia group. Anecdotally, incisional hernias are thought of as larger and thus more clinically evident, but these results show that there may be a subset of patients with equivocal hernias amenable to effective ultrasound diagnosis.

Nonetheless, the hernia size data are subject to numerous confounding factors, and this should be taken into consideration. For example, it is assumed that the ultrasound images were

taken when the hernia was at its largest, which may not be the case, or the Valsalva manoeuvre may not have been performed with the same intensity for the clinical examination as during the ultrasound scan.

As ultrasound is known to be operator dependent,³ a variety of skill levels were necessarily present in the large number of different practitioners in this study. Despite this, excellent results were obtained, suggesting that these results are readily reproducible in other centres which might employ a similar setup.

Due to the retrospective nature of this study, a true sensitivity and specificity cannot be accurately calculated; the figures given pertain only to those who underwent surgery. It is possible that a higher proportion of patients who were not operated on were false-positives. These patients could only be tested against cross-sectional imaging, but not against the gold standard of surgery.

Nonetheless, of the patients who were operated on, a sensitivity of 91.8% and positive predictive value of 97.8% is comparable to several other studies assessing the accuracy of inguinal or

femoral hernias. These ranged from 80% to 100% for sensitivity and positive predictive values ranging from 71% to 100%.⁴⁻¹¹ Other studies have attempted to compare ultrasound with CT scans, but none have compared it with surgical findings.¹⁰

The closest study comparing ventral hernia ultrasound results with surgical findings was by Spangen in 1975, who reported an accuracy of 85.3% in a cohort of 34 patients.¹² There have been significant advances in the quality and resolution of ultrasound scanning machines in the intervening 40 years, but the complexity of cases has also increased; our study only included equivocal cases. If ultrasound was considered a valuable adjunct in the past, the authors consider it more so in the present.

CONCLUSION

This study confirms that dynamic ultrasound scanning is an effective and valuable tool in the diagnosis of equivocal ventral hernias.

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