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Systematic Review and Meta-analysis**
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Diagnostic Performance of Ultrasound in Nonpalpable Cryptorchidism: A Systematic Review and Meta-analysis

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abstract

CONTEXT: Ultrasound is frequently obtained during the presurgical evaluation of boys with nonpalpable undescended testes, but its clinical utility is uncertain.

OBJECTIVE: To determine the diagnostic performance of ultrasound in localizing nonpalpable testes in pediatric patients.

METHODS: English-language articles were identified by searching Medline, Embase, and the Cochrane Library. We included studies of subjects younger than 18 years who had preoperative ultrasound evaluation for nonpalpable testes and whose testis position was determined by surgery. Data on testis location determined by ultrasound and surgery were extracted by 2 independent reviewers, from which ultrasound performance characteristics (true-positives, false-positives, false-negatives, and true-negatives) were derived. Meta-analysis of 12 studies (591 testes) was performed by using a random-effects regression model; composite estimates of sensitivity, specificity, and likelihood ratios were calculated.

RESULTS: Ultrasound has a sensitivity of 45% (95% confidence interval [CI]: 29−61) and a specificity of 78% (95% CI: 43−94). The positive and negative likelihood ratios are 1.48 (95% CI: 0.54−4.03) and 0.79 (95% CI: 0.46−1.35), respectively. A positive ultrasound result increases and negative ultrasound result decreases the probability that a nonpalpable testis is located within the abdomen from 55% to 64% and 49%, respectively. Significant heterogeneity limited the precision of these estimates, which was attributable to variability in the reporting of selection criteria, ultrasound methodology, and differences in the proportion of intraabdominal testes.

CONCLUSIONS: Ultrasound does not reliably localize nonpalpable testes and does not rule out an intraabdominal testis. Eliminating the use of ultrasound will not change management of nonpalpable cryptorchidism but will decrease health care expenditures. *Pediatrics* 2011;127:119−128

Cryptorchidism (undescended testis) is the most common congenital genitourinary anomaly in boys and has a prevalence of 1% to 3% in term and 15% to 30% in premature male infants; of these testes, 10% to 20% are nonpalpable.[1,2] Cryptorchidism is associated with impaired fertility, inguinal hernia, and increased risk of testis cancer.[3–5] Primary care providers usually diagnose cryptorchidism during routine checkups, at which time the child is referred to a pediatric urologist or surgeon who performs surgical correction (orchiopexy), ideally before the child is 12 months of age.[6,7]

The operative approach is based on the palpability of the testis. When the testis is palpable, an inguinal or prescrotal orchiopexy is performed. On the other hand, a nonpalpable testis may be present in the inguinal-scrotal region or within the abdominal cavity, or it may be entirely absent. Surgical exploration is compulsory to localize the testis when present or confirm an absent testis by revealing blind-ending spermatic vessels or a nonviable nubbin. However, accurate presurgical diagnosis of an absent testis would spare a child an operation, and correct localization of a testis could limit the extent of surgery. For this reason, a majority of pediatricians obtain ultrasounds to locate undescended testes, especially when the testis is nonpalpable.[8] Observational studies conducted with pediatric patients over the last 25 years have revealed limited and sometimes conflicting diagnostic performance characteristics, such as sensitivity and specificity, but have not rigorously evaluated the clinical utility of ultrasound in localizing nonpalpable testes.[9,10]

Given the frequent use but uncertain utility of ultrasound in evaluating boys with cryptorchidism, we performed a systematic review and meta-analysis of published studies to determine if
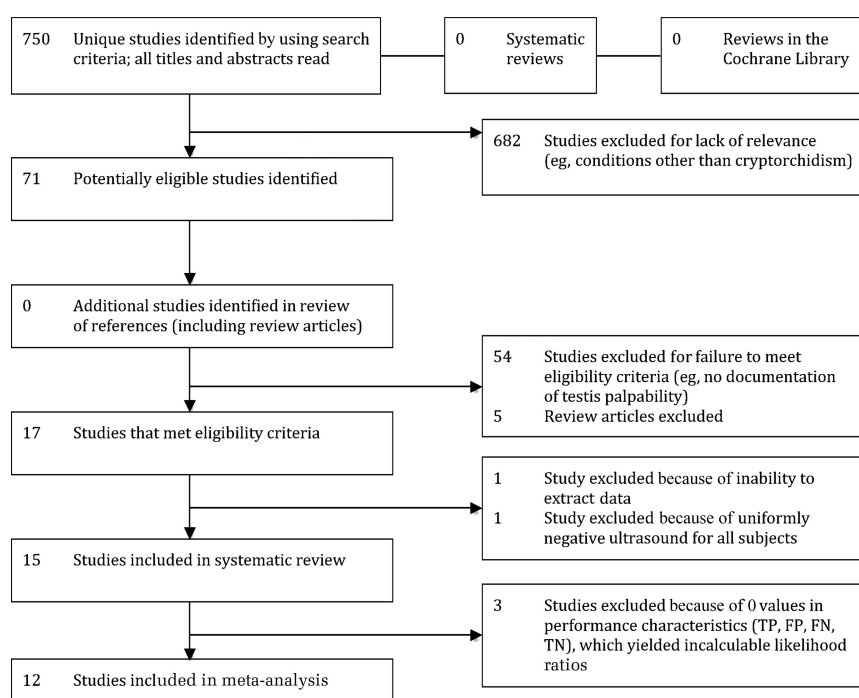

FIGURE 1
Selection process for study inclusion.

preoperative ultrasound evaluation is sufficient to direct surgical management of boys with nonpalpable testes.

METHODS

Data Sources

We searched Medline, Embase, and the Cochrane Library from their inceptions to March 2010 for published articles on ultrasound evaluation of children with nonpalpable undescended testes. In consultation with a research librarian experienced in systematic reviews, articles were identified by using the following search concepts: "cryptorchidism," "nonpalpable testes," "orchiopexy," and "ultrasonography." The explosion feature of each database was used, the search was limited to English-language publications, and animal studies were excluded (see Appendix for search-strategy details). In addition, the bibliographies of all potentially relevant primary articles ($n =$ 66) and review articles ($n = 5$) identified in the search were read to identify

other relevant articles not detected in the database search.

Study Selection

Articles were independently reviewed and selected by both of us. We included studies of subjects between 0 and 18 years of age who had ultrasound evaluation for nonpalpable testes and whose testis position was definitively determined by surgery. We excluded case reports, reviews, expert opinions, editorials, and studies in which testis location determined by ultrasound and/or surgery was not sufficiently described (Fig 1). To reduce selection bias, we excluded studies for which the reported outcome was the result of surgical exploration for subjects who all had ultrasounds that did not localize a testis ($n = 1$).[11]

Data Extraction

Working independently, we abstracted data from the studies that met eligibility criteria ($n = 15$). Disagreement

was resolved by discussion, after which consensus was achieved in all cases. Our outcome measures were testis location as determined by ultrasound and surgery. For each study, we extracted data on testis location as determined by ultrasound and surgery and entered ultrasound performance characteristics (true-positives [TPs], false-positives [FPs], false-negatives [FNs], and true-negatives [TNs]) into 2×2 tables. The location of the testis at the time of surgery was treated as the gold standard and was the reference test against which ultrasound performance was measured. For example, a testis that was detected by ultrasound in the inguinal-scrotal region and was found to be in that location during surgery was recorded as a TP, whereas a testis that was not visualized by ultrasound but was found to be intraabdominal during surgery was recorded as an FN. Testes at or just proximal to the internal inguinal ring (peeping testes) were recorded as intraabdominal. These tables were constructed for the overall data set and, when possible, for subgroups. The subgroup analysis was performed to determine the sensitivity and specificity of ultrasound in localizing nonpalpable inguinal-scrotal ($n = 4$ studies) and intraabdominal ($n = 5$ studies) testes.

Statistical Analysis

For each study, the sensitivity and specificity of ultrasound in localizing nonpalpable testes were calculated. Pooled estimates of sensitivity, specificity, and positive and negative likelihood ratios for the overall data set and the subgroup analysis were calculated by using a random-effects regression model using the method of DerSimonian and Laird.[12] We calculated sensitivity as TP/(TP + FN), specificity as TN/(FP + TN), the likelihood ratio for a positive test result as (TP/[TP + FN])/(FP/[FP + TN]), and the likelihood ratio for a negative result as (FN/[TP + FN])/

(TN/[FP + TN]). The Cain et al,[13] Graif et al,[14] and Elder[9] studies were excluded from the regression model, because 0 values for 2 or more individual performance characteristics (eg, FP and TN) precluded calculation of likelihood ratios. Interstudy heterogeneity was assessed with the I^2 score; we considered an I^2 score of >30% indicative of significant heterogeneity.[15]

We used Bayes theorem to calculate the posterior probability of testis location after ultrasound evaluation. Posterior probability is the probability of an event (testis location) taking into account other relevant evidence (ultrasound findings). The pretest probability of testis location was set at the mean anatomic distribution of nonpalpable testes reported in published studies of consecutive subjects in whom testis location was prospectively recorded at the time of surgery. The pretest probabilities were 30% for inguinal-scrotal testes, 55% for intraabdominal testes, and 15% for absent testes.[16–18] These probabilities were converted to pretest odds. The pretest odds and likelihood ratios were used to determine the posttest odds with the following formula: posttest odds = pretest odds $\times$ likelihood ratio. Posterior probability was generated by subsequent conversion of the posttest odds to a probability. Because interstudy heterogeneity limited the reliability of the likelihood-ratio estimates, posterior probabilities were calculated by using both the point estimate and the upper and lower confidence limits (CLs) for the positive and negative likelihood ratios, respectively. This analysis was performed to correct for the possibility that interstudy heterogeneity caused the model to underestimate ultrasound performance.

Working independently, we assessed the quality of individual studies by using the Quality Assessment of Diagnostic Accuracy Studies (QUADAS) crite-

ria.[19] We then performed univariate meta-regression to explore the a priori hypothesis that interstudy differences in the QUADAS criteria could account for the observed heterogeneity. Each of the 14 QUADAS criteria was categorized as a dichotomous variable (yes versus no/unclear) and included in the meta-regression model. We also determined whether the proportion of inguinal-scrotal and intraabdominal testes (determined by surgery) for each study was within 10 percentage points of the proportions reported in the literature and included this covariate in the meta-regression. The aforementioned pretest probabilities were used as the reference values for this determination.[16–18] Categorization of testicular location was performed because inguinal-scrotal testes are more likely and intraabdominal testes are less likely to be identified by ultrasound; therefore, studies with markedly different proportions of inguinal-scrotal or intraabdominal testes would affect the reported sensitivity.

Studies with sensitivity and specificity estimates that were outliers were identified by using the bag plot, as described by Rousseeuw et al.[20] A sensitivity analysis was then performed by removing the outlying studies from the meta-analysis regression model to determine if they had a significant effect on the composite estimates of the performance parameters. Publication bias was assessed by funnel-plot analysis.[21] Tests were 2-sided, and $P < .05$ was used as the threshold for statistical significance. Analyses were performed by using Stata 11 (Stata Corp, College Station, TX).

RESULTS

Literature Search

The search yielded 750 unique references. No additional studies were identified from review of article references. No previous systematic reviews were identified through search of Med-

line, Embase, or the Cochrane Library. Of the 750 articles, 66 (8.8%) were potentially relevant. A total of 15 (2%) studies met our eligibility criteria, from which data on 696 nonpalpable testes were extracted (Table 1).[9,10,13,14,22–32] There were no discrepancies in the extracted data or in the quality assessment of the studies between the two of us. Eight (53%) studies were prospective, 6 (40%) were retrospective, and not enough details were provided by 1 study (7%) to determine study design. A pediatric urologist or pediatric surgeon performed the preoperative physical examination of the included subjects in all studies. The examination was performed in the office in all studies; however, an examination under anesthesia was also performed in the Atlas and Stone,[25] Ismail et al,[32] and Nijs et al[31] studies.

Determination of Diagnostic Performance

Meta-analysis of 12 studies (591 testes) was performed after the Cain et al,[13] Graif et al,[14] and Elder[9] studies were excluded because of insufficient data necessary to calculate likelihood ratios. The composite sensitivity and specificity of ultrasound in localizing a nonpalpable undescended testis were 45% (95% confidence interval [CI]: 29–61) and 78% (95% CI: 43–94), respectively. The composite likelihood ratios for a positive and negative ultrasound result were 1.48 (95% CI: 0.54–4.03) and 0.79 (95% CI: 0.46–1.35) (Fig 2), respectively. Ultrasound differed in its ability to reliably localize testes in different anatomic sites. Ultrasound detected 88 (97%) viable inguinal testes, 15 (30%) nonviable inguinal "nubbins," and 21 (38%) intraabdominal testes. The sensitivity and specificity of ultrasound in detecting nonpalpable inguinal-scrotal testes were 52% (95% CI: 27–75) and 88% (95% CI: 33–99), respectively. The sensitivity and specificity of ultrasound in detecting nonpalpable intraabdominal testes were 44% (95% CI: 22–68) and 93% (95% CI: 34–100), respectively.

The pretest probability that a nonpalpable testis was within the abdomen was ~55%.[16–18] Using the likelihood-ratio point estimates, the posterior probability that a nonpalpable testis was intraabdominal after a positive and negative ultrasound result was 64% and 49%, respectively. When using the upper CL of the positive likelihood ratio, the posterior probability that a nonpalpable testis was truly intraabdominal after an ultrasound localized a testis within the abdomen was 83%. When using the lower CL of the negative likelihood ratio, the posterior probability that a nonpalpable testis was intraabdominal after an ultrasound did not localize any testis was 36% (Fig 3).

The sensitivity analysis identified 3 outlying studies: Liu et al,[29] Shah and Shah,[30] and Ismail et al.[32] Removing these studies produced similar performance parameters to the complete data-set estimates: the composite sensitivity was 44% (95% CI: 27–66), and specificity was 82% (95% CI: 67–91). These values yielded positive and negative likelihood ratios of 2.21 (95% CI: 1.24–3.93) and 0.66 (95% CI: 0.46–0.96), respectively. Using the point estimates from the sensitivity

TABLE 1 Characteristics of Included Studies That Assessed Diagnostic Performance of Ultrasound in Localizing Nonpalpable Undescended Testes

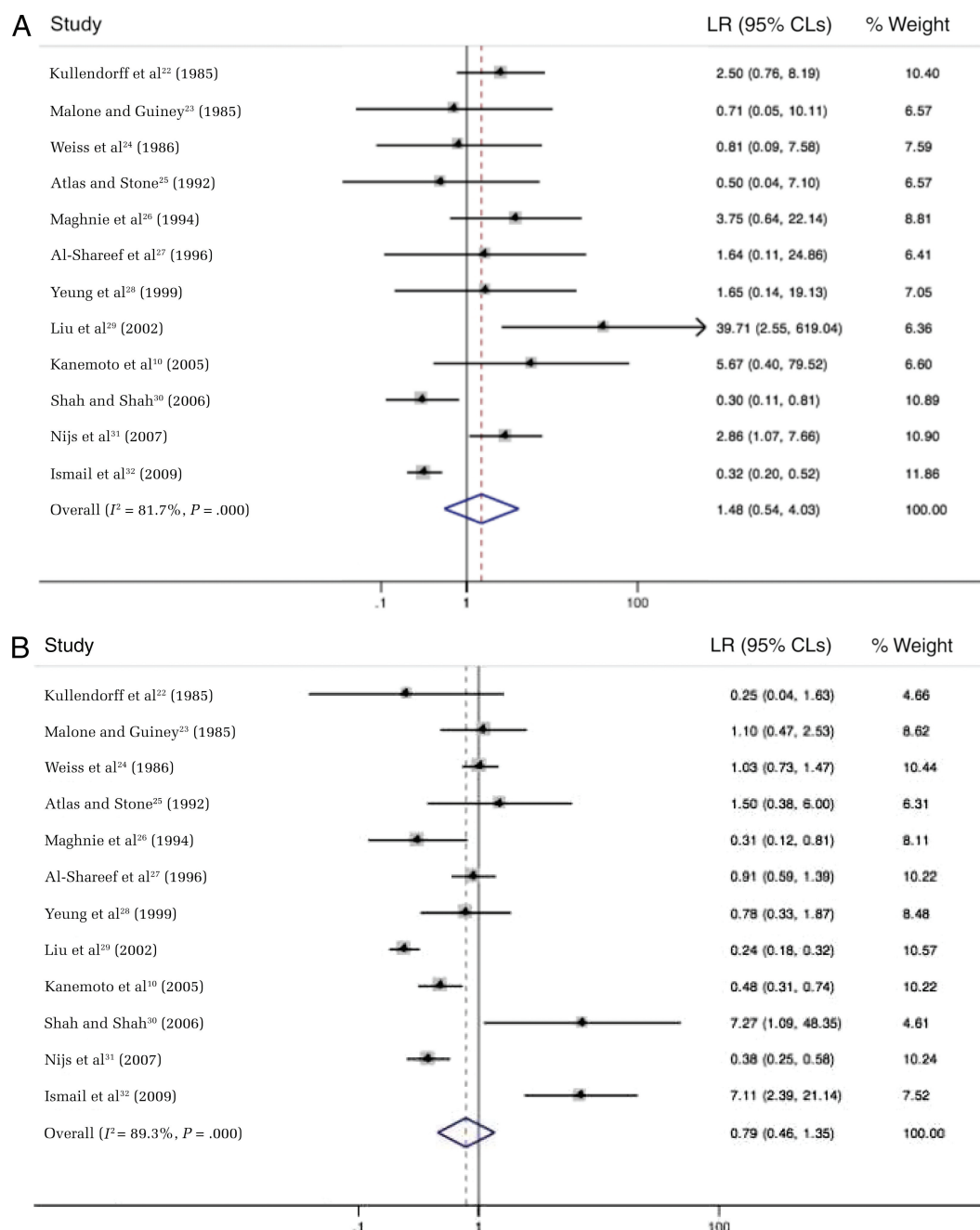| Study	Patients, n	Testes, n	Sensitivity, SD[a]	Specificity, SD[a]	Inguinal-Scrotal Testes, n (%)	Abdominal Testes, n (%)	Absent Testes, n (%)	QUADAS Criteria Met, n (SD)[b]
Kullendorff et al[22] (1985)	12	12	0.83	0.67	5 (42)	1 (8)	6 (50)	9
Malone and Guiney[23] (1985)	11	14	0.15	1.00	6 (43)	7 (50)	1 (7)	10
Weiss et al[24] (1986)	Unknown	21	0.13	0.85	5 (24)	3 (14)	13 (62)	10
Graif et al[14] (1990)[c]	Unknown	8	1.00	0.00	NA	2 (25)	NA	10
Atlas and Stone[25] (1992)	3	3	0.00	0.50	1 (33)	0 (0)	2 (67)	11
Maghnie et al[26] (1994)	17	21	0.75	0.80	10 (48)	6 (28)	5 (24)	10
Al-Shareef et al[27] (1996)	19	24	0.19	1.00	5 (21)	16 (67)	3 (12)	12
Cain et al[13] (1996)	64	74	0.64	—[d]	63 (85)	11 (15)	0 (0)	12
Yeung et al[28] (1999)	21	23	0.41	1.00	18 (78)	4 (17)	1 (4)	12
Liu et al[29] (2002)	150	170	0.77	1.00	122 (72)	23 (13)	25 (15)	12
Elder[9] (2002)[c]	Unknown	21	0.00	1.00	NA	10 (48)	NA	11
Kanemoto et al[10] (2005)	46	55	0.57	1.00	48 (87)	3 (5)	4 (7)	11
Shah and Shah[30] (2006)	23	23	0.27	0.10	10 (43)	12 (52)	1 (4)	10
Nijs et al[31] (2007)	135	152	0.71	0.75	108 (71)	35 (23)	9 (6)	12
Ismail et al[32] (2009)	64	75	0.29	0.10	17 (23)	43 (57)	15 (20)	11
Total	—	696	0.44 (0.33)	0.70 (0.37)	418 (60)	176 (25)	96 (14)	10.87 (0.99)

NA indicates not applicable.

[a] The sensitivity and specificity values shown are exact calculations.

[b] There are a total of 14 QUADAS criteria, and the number of criteria met by each study are shown to provide a general idea of the quality of the included studies. The QUADAS criteria have not been validated as a numerical score given that the emphasis placed on each criterion will vary depending on the diagnostic test being assessed.

[c] The surgical locations were not given for all testes, which accounts for the missing data in the columns for inguinal-scrotal and absent testes. The studies did specify the number of TPs, FPs, FNs, and TNs, which allowed for calculation of the overall ultrasound-performance parameters.

[d] Specificity could not be calculated because, no FPs or TNs were reported.

A Study

Study	LR (95% CLs)	% Weight
Kullendorff et al[22] (1985)	2.50 (0.76, 8.19)	10.40
Malone and Guiney[23] (1985)	0.71 (0.05, 10.11)	6.57
Weiss et al[24] (1986)	0.81 (0.09, 7.58)	7.59
Atlas and Stone[25] (1992)	0.50 (0.04, 7.10)	6.57
Maghnie et al[26] (1994)	3.75 (0.64, 22.14)	8.81
Al-Shareef et al[27] (1996)	1.64 (0.11, 24.86)	6.41
Yeung et al[28] (1999)	1.65 (0.14, 19.13)	7.05
Liu et al[29] (2002)	39.71 (2.55, 619.04)	6.36
Kanemoto et al[10] (2005)	5.67 (0.40, 79.52)	6.60
Shah and Shah[30] (2006)	0.30 (0.11, 0.81)	10.89
Nijs et al[31] (2007)	2.86 (1.07, 7.66)	10.90
Ismail et al[32] (2009)	0.32 (0.20, 0.52)	11.86
Overall ($I^2 = 81.7\%$, $P = .000$)	1.48 (0.54, 4.03)	100.00

B Study

Study	LR (95% CLs)	% Weight
Kullendorff et al[22] (1985)	0.25 (0.04, 1.63)	4.66
Malone and Guiney[23] (1985)	1.10 (0.47, 2.53)	8.62
Weiss et al[24] (1986)	1.03 (0.73, 1.47)	10.44
Atlas and Stone[25] (1992)	1.50 (0.38, 6.00)	6.31
Maghnie et al[26] (1994)	0.31 (0.12, 0.81)	8.11
Al-Shareef et al[27] (1996)	0.91 (0.59, 1.39)	10.22
Yeung et al[28] (1999)	0.78 (0.33, 1.87)	8.48
Liu et al[29] (2002)	0.24 (0.18, 0.32)	10.57
Kanemoto et al[10] (2005)	0.48 (0.31, 0.74)	10.22
Shah and Shah[30] (2006)	7.27 (1.09, 48.35)	4.61
Nijs et al[31] (2007)	0.38 (0.25, 0.58)	10.24
Ismail et al[32] (2009)	7.11 (2.39, 21.14)	7.52
Overall ($I^2 = 89.3\%$, $P = .000$)	0.79 (0.46, 1.35)	100.00

FIGURE 2
Forest plot of positive (A) and negative (B) likelihood ratios. The dot refers to the point estimate for the likelihood ratio, and the lines represent the 95% CLs. Box size is proportional to the weight given to the study and is based on the study sample size and variance. The vertical line denotes the summary likelihood ratio, and the diamond represents the associated 95% CLs. Note that weights are from random-effects analysis.

analysis, the posterior probability that a nonpalpable testis was intraabdominal after a positive and negative ultrasound result was 73% and 45%, respectively. Using the upper CL of the positive likelihood ratio to provide an estimate of ultrasound's best performance ability, the posterior probability that a nonpalpable testis was truly intraabdominal after an ultrasound localized a testis within the abdomen was 83%. Using the lower CL of the negative likelihood ratio, the posterior probability that a nonpalpable testis was intraabdominal after ultrasound did not localize any testis was 36%.

Study Quality, Heterogeneity, and Publication Bias

The included studies met a median of 11 of the 14 QUADAS criteria (range: 9–12). The quality items that were most often not included or not adequately reported by the included stud-
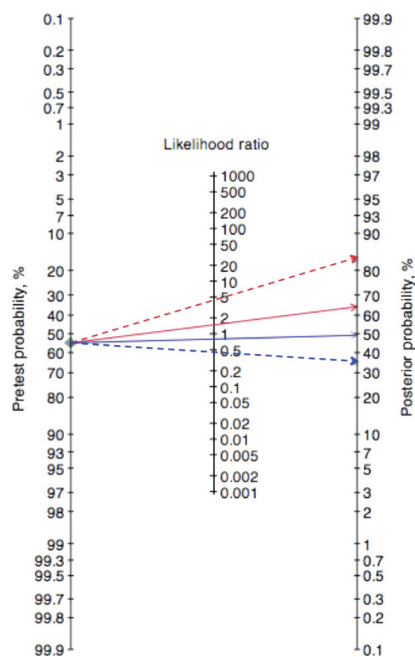
FIGURE 3
Effect of ultrasound on the probability of testis location. The pretest probability that a nonpalpable testis is within the abdomen is 55%. Using the positive likelihood-ratio point estimate (solid red line) and upper CL (dashed red line), an ultrasound that localizes a nonpalpable testis within the abdomen increases the probability that the testis is truly in the abdomen to 64% and 83%, respectively. Using the negative likelihood-ratio point estimate (solid blue line) and lower CL (dashed blue line), an ultrasound that does not visualize a nonpalpable testis decreases the probability that the testis is truly in the abdomen to 49% and 36%, respectively.

ies were descriptions of subject-selection criteria and ultrasound methodology (eg, specification of ultrasound transducer frequency) and having the physical examination findings available to the ultrasonographer, which is information that should be available in clinical practice.

There was significant interstudy heterogeneity in the summary positive ($I^2 = 81.7\%$) and negative ($I^2 = 89.3\%$) likelihood-ratio estimates. A meta-regression model was used to identify specific aspects of the included studies that might have accounted for the observed heterogeneity. The model included 15 different study characteristics, of which 2 were found to have a statistically significant effect on the

pooled sensitivity estimate: (1) differences between the proportion of intra-abdominal testes ($\beta = .16$; 95% CI: 0.01–0.3; $P = .03$); and (2) variability in the adequacy of ultrasound-methodology description ($\beta = .64$; 95% CI: 0.45–0.84; $P = .03$). One study characteristic had a significant effect on the pooled specificity estimate: variability in the adequacy of subject-selection criteria reporting ($\beta = .91$; 95% CI: 0.76–1.00; $P = .03$). In the sensitivity analysis, heterogeneity was eliminated for the positive likelihood ratio ($I^2 = 0\%$) and reduced for the negative likelihood ratio ($I^2 = 67.6\%$). There was no evidence of publication bias in the included studies ($P = .55$).

DISCUSSION

Summary of Findings

In this systematic review of 15 studies and meta-analysis of 12 studies that assessed the diagnostic performance of preoperative ultrasound in localizing nonpalpable testes, we found that ultrasound performs poorly as a diagnostic test. Even using the most generous estimates of ultrasound performance, ultrasound does not reliably localize nonpalpable testes. Ultrasound cannot differentiate nonviable nubbins from surrounding inguinal tissue, and bowel gas often precludes localization of intraabdominal testes. We cannot fairly evaluate whether ultrasound changed the operative approach in the studies included in the meta-analysis, because in all studies, except that of Nijs et al,[31] the same operative approach was performed regardless of the ultrasound findings. However, results of the analysis performed clearly show that the change in the probability of the location of a nonpalpable testis conferred by ultrasound was small, and there was still a significant chance that a testis was present after a negative ultrasound result. From this result we conclude that

abdominal-scrotal ultrasound is unnecessary in the preoperative evaluation of boys with nonpalpable testis, because it would not change the surgical management of boys with the condition.

We found significant heterogeneity among the included studies, which was a result of differences in the quality and subject characteristics between studies. This heterogeneity limited the reliability and precision of the calculated performance-criteria estimates, including the likelihood ratios. Indeed, meta-analysis of the 12 included studies produced CIs for the positive and negative likelihood-ratio estimates that crossed 1. For this reason, we also calculated the posterior probability of testis location after ultrasound by using the likelihood-ratio CLs, which was done to maximize ultrasound performance and control for the possibility that the likelihood-ratio point estimates underestimated the true performance of ultrasound. We also tested the durability of our results by performing a sensitivity analysis in which the outlying studies were removed from the model. When comparing these analyses, the posterior probabilities were similar when using the likelihood-ratio point estimates and identical when using the likelihood-ratio CLs. All analyses revealed that ultrasound changes the probability of testis location to a degree far less than is needed to make surgical decisions. However, given the significant heterogeneity of the data, we caution against ascribing any specific value to the ability of ultrasound to increase or decrease the likelihood of the true location of a nonpalpable testis. In addition, although we used 3 representative studies to calculate the pretest probability of testis location, using the proportions of testis location from other well-designed studies will produce different posterior probabilities.[33]

In our exploration of the causes of this heterogeneity, we found that the reporting of selection criteria, description of ultrasound techniques, and differences in the proportions of abdominal testes had effects on the sensitivity and specificity estimates. Because the reporting of ultrasound technique was poor, it is possible that different-frequency ultrasound probes were used, which may have affected the ability of ultrasound to differentiate a testis from a lymph node. It is possible that unaccounted differences in the study subjects, such as obesity or the presence of contralateral testis hypertrophy, which suggests an absent or nonviable nonpalpable testis, contributed to the heterogeneity given that the selection criteria and subject characteristics were often poorly reported.[34,35] In addition, the proportions of subjects with intraabdominal testes reported in the included studies varied and, most often, were lower than the reference values. Further investigation revealed that of the 10 studies with a proportion of abdominal testes that differed from that of the reference value, 9 (90%) reported proportions of intraabdominal testes of <40%. As found in the subgroup analysis, abdominal testes are less likely to be identified by ultrasound. Therefore, the true sensitivity of ultrasound in localizing nonpalpable testes may be less than the estimates we reported. Finally, although not quantified, it is also likely that ultrasound operator technique accounted for some of the interstudy heterogeneity given the operator-dependent nature of ultrasound.

Strengths and Limitations

We used expansive search strategies to identify all relevant studies that assessed the diagnostic performance of ultrasound in localizing nonpalpable undescended testes. To our knowledge, this is the first systematic review of this literature and the first study to quantify, in a statistically rigorous fashion, the diagnostic performance and clinical utility of ultrasound in localizing nonpalpable testes. As mentioned, the main limitation is the significant heterogeneity of the included studies, which limits the reliability of the calculated pooled performance criteria. However, our regression model accounted for heterogeneity, we explored causes of interstudy variability, and our analysis met the recommended standards for meta-analyses of observational studies.[36] Furthermore, excluding the Liu et al,[29] Shah and Shah,[30] and Ismail et al[32] studies eliminated the heterogeneity in the positive likelihood ratio and reduced the heterogeneity in the negative likelihood ratio. Although the remaining studies were indeed more alike with respect to the study characteristics identified as significant factors in causing the observed heterogeneity, they were not identical, which suggests that other unidentified study characteristics contributed to the reported sensitivity and specificity being significantly higher in the Liu et al[29] study and significantly lower in the Shah and Shah[30] and Ismail et al[32] studies than the other studies. Second, we intentionally excluded meeting abstracts from our search strategy to reduce data heterogeneity because of the high prevalence of inadequate reporting in abstracts and inconsistencies between abstracts and subsequent full-length articles of observational studies.[37] Also, we limited the search to English-language articles; however, it is unlikely that including articles printed in other languages would have affected our results.[38] An additional limitation is the incomplete adherence of the included studies to the QUADAS criteria.

Relation to Clinical Practice

Although patients with nonpalpable testes and ambiguous genitalia should have diagnostic imaging evaluation, the results of our analysis do not support the routine use of ultrasound in the evaluation of boys with nonpalpable testes.[39] Physical examination, even for obese children, is the most important aspect of the presurgical assessment of a boy with an undescended testis.[34] All boys with nonpalpable undescended testes require surgical exploration to bring a viable testis down to the scrotum, remove nonviable testicular tissue identified in the exploration, or to confirm the congenital absence of a testis. To accomplish these goals, the urologist or surgeon will either perform diagnostic laparoscopy or an inguinal exploration, depending on surgeon preference.[40–44] However, if ultrasound could reliably determine the presence and location of a nonpalpable testis, a child could be spared an operation (in the setting of an absent testis) or could undergo a more limited operation restricted to where the testis was seen on ultrasound. We found that ultrasound did not have the diagnostic power necessary to change the standard surgical algorithm.

Indeed, reliance on ultrasound findings can have severe and deleterious consequences. If a urologist decides not to operate on a child with a nonpalpable testis that was not visualized by ultrasound, there is still, with the most conservative estimate (Fig 3), a 36% probability that the testis is within the abdomen. Should this testis be present, not operating potentially increases the risk of testicular carcinoma, which, given the intraabdominal location of the testis, places the child at a higher risk for presentation with advanced disease because of the inability to perform routine screening physical examinations.[5,45]

Implications for the Health Care System

Among Medicare beneficiaries with cancer, the cost of diagnostic imaging is rising 5% to 10% per year, which is more than double the total rate of increase of Medicare expenditures.[46] Although large-scale studies on the global cost of diagnostic imaging in the pediatric population have been lacking, imaging is not less expensive per pediatric patient. At our institution, an abdominal-scrotal ultrasound to evaluate undescended testes costs $2194. The lack of population-level data makes it difficult to generate an average cost of abdominal-scrotal ultrasound, because charges vary according to patient insurance status, region of the country, and where the examination was performed (hospital outpatient versus freestanding imaging center). However, we do know that ultrasound is used heavily in the presurgical evaluation of boys with cryptorchidism.[8] Given the high utilization rate of ultrasound and an estimated cost per abdominal-scrotal ultrasound of $500 to $2000, the yearly cost of ultrasound evaluation of undescended testes would likely be along the order of tens of millions of dollars.

The US Department of Health and Human Services recently reported that health care expenses will increase after implementation of the Patient Protection and Affordable Care Act.[47] We must develop new ways to decrease costs and improve resource utilization. Just as physicians have a duty to provide diagnostic tests and therapies that bring maximum benefit to patients, we also are obligated to identify those health care resources that confer limited benefit to patients but add significant cost to the health care system. Recently, Brody[48] proposed a "top-5 list" in which he called for all medical specialties to identify and recommend against using heavily used and expensive diagnostic tests that offer little benefit for whom they are ordered. Our findings demonstrate that ultrasound used to evaluate cryptorchidism meets these criteria. Thus, we recommend against using ultrasound to evaluate children with cryptorchidism. Embracing the opportunity to eliminate unnecessary utilization of health care resources will allow physicians to continue to advocate for their patients and also act as stewards for a fragile health care system.

CONCLUSIONS

Ultrasound has no clinical utility in the routine presurgical evaluation of boys with nonpalpable testes. Eliminating the use of ultrasound in this setting will not deleteriously affect those with cryptorchidism and will not change management of the condition, but it will decrease health care expenditures.

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APPENDIX Representative Search Strategy: Medline (Using PubMed)

1. Cryptorchidism
2. Cryptorchism
3. Undescended testis[tw]
4. Undescended testes[tw]
5. Maldescended testis[tw]
6. Maldescended testes[tw]
7. Nonpalpable testis[tw]
8. Nonpalpable testes[tw]
9. Non-palpable testis[tw]
10. Non-palpable testes[tw]
11. Impalpable testis[tw]
12. Impalpable testes[tw]
13. Orchiopexy
14. Orchidopexy
15. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14
16. Ultrasonography
17. Ultrasound
18. Ultraso*
19. Sonogra*
20. Echogra*
21. 16 or 17 or 18 or 19 or 20
22. 15 and 21
23. 22 and eng[LA]
24. 23 not (animals[mh] not humans[mh])

Note that the same search strategy was used to search Embase and the Cochrane library.

Updated Information & Services	including high-resolution figures, can be found at: http://www.pediatrics.org/cgi/content/full/127/1/119
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