The Bedside Assessment of Splenic Enlargement

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STUDY OBJECTIVE: To evaluate the clinical assessment of splenic enlargement using specific bedside maneuvers including Traube's space percussion, the splenic percussion sign, Middleton's maneuver, supine palpation, and right lateral decubitus palpation.

DESIGN: Quasi-experimental prospective study of cases and controls selected according to the results of abdominal ultrasonographic examinations.

SETTING: Selected inpatients of a tertiary care hospital.

MAIN RESULTS: Comparing the areas under the receiver operating characteristic curves for each bedside maneuver demonstrated that Traube's space percussion and palpation were significant discriminators ($p < 0.001$) of splenic enlargement with respective areas of 0.70 ± 0.04 and 0.76 ± 0.04. No one palpation maneuver was superior to another, and right lateral decubitus palpation was not useful when performed after supine palpation. The splenic percussion sign (sensitivity 79%, specificity 46%) was no better than Traube's space percussion (sensitivity 62% and specificity 72%) in assessing splenic enlargement. The palpation maneuvers appeared more sensitive and more specific than Traube's space percussion. Palpation was a significant clinical discriminator when performed on patients who exhibited percussion dullness of Traube's space (area = 0.87 ± 0.04, $p < 0.0001$) but was of little value among those without percussion dullness (area = 0.55 ± 0.08). Also, palpation was significantly more accurate when performed on lean patients versus obese patients (areas = 0.83 ± 0.04 versus 0.65 ± 0.08, $p < 0.05$). When a positive bedside examination was defined as positive palpation and positive percussion (concordant-positive), the combined test sensitivity and specificity were 46% and 97% respectively.

CONCLUSIONS: The optimal clinical assessment of splenic enlargement includes the percussion of Traube's space. If Traube's space is dull, palpation of the spleen is warranted. This assessment is most accurate in lean patients.

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In this era of expanding technology, medical professionals often overlook the evaluation of "old technologies." However, the initial patient assessment still relies on the history and physical examination. The patient encounter can be considered as a series of screening tests constantly modifying the probability of disease for a given patient in the diagnostic physician's mind [1].

In a previous report, we defined the usefulness of Traube's space percussion in assessing splenic enlargement [2]. Using the same patient population, we have determined the diagnostic accuracy of the physical examination of the spleen employing various percussion and palpation maneuvers in addition to Traube's space percussion; these include the splenic percussion sign [3,4], supine and right lateral decubitus palpation, and Middleton's maneuver [5]. After studying the performance of these maneuvers both individually and in series, we suggest an optimal approach to the clinical detection of an enlarged spleen.

PATIENTS AND METHODS

Patient Sample

All patients admitted to the Montreal General Hospital who had undergone an abdominal ultrasound examination within the preceding 2 months were eligible for inclusion in the study. Over a 4-month period, a weekly review of all inpatient sonographic examinations was performed by one of the authors (ANB) to identify both subjects with splenic enlargement and appropriate control subjects with normal-sized spleens. Patients were excluded from the study if the ultrasonogram was deemed to be technically inadequate.

All patients with enlarged spleens on ultrasound were included in the study. Control patients were chosen from sonograph reports following a systematic sampling procedure modified to allow balancing of the two groups for age, sex, height, and weight [6]. The actual prevalence of enlarged spleens in the patient population was not predetermined and var-

ied from week to week. Thus, the clinicians did not know the expected number of patients with enlarged spleens for a given week. Because of the concern that specific bedside clues might bias the examiners in their clinical assessments, adjustment was also made for the presence of stigmata of liver disease including jaundice, ascites, and telangiectasias as noted on the admitting physical or during the study examinations. Although the study population originated from general and specialty wards including medical, surgical, gynecologic, and psychiatric services, the patients were balanced according to the location of their room (hematology floor or a nonhematology ward), to avoid bias based on ward descriptions.

Clinical Data Collection and Bedside Examinations

Clinical data were abstracted by one of the authors (ANB) from the hospital admission record and included age, sex, height, weight, presence of stigmata of liver disease, and the ward where the patient was located.

Each patient was to be examined by the same three board-certified internists (LG, TM, SAG) without knowledge of the patient's history, other physical findings, or ultrasound results. The internists were asked to examine only the patient's abdomen and not to look for clinical evidence of diseases associated with splenic enlargement. However, the presence of visible ascites, jaundice, or telangiectasias was recorded. Each clinician visited the patient in his or her ward bed after obtaining verbal consent for the examination. Resulting data were recorded at the bedside.

Clinical Maneuvers

For the purposes of our study, Traube's space was defined as an area delineated by the sixth rib superiorly, the midaxillary line laterally, and the left costal margin inferiorly. This triangle was percussed from its medial to its lateral margin. Each examiner scored the Traube's space percussion note on a five-point scale: 1 = definitely tympanitic, 2 = probably tympanitic, 3 = uncertain, 4 = probably dull, 5 = definitely dull. The patients were then examined using the splenic percussion sign, in which percussion was carried out at a point where the lowest intercostal space (eight or ninth) crossed the left anterior axillary line [3,4]. Using the same five-point grading scale, percussion was carried out initially on end expiration, and then on deep inspiration [3]. All patients with a percussion of grade 4 or more on end expiration were considered to have a positive splenic percussion sign; moreover, if the percussion on end expiration was 1, 2, or 3 (using the same percussion note grading as mentioned above), the splenic percussion sign was said to be positive if the percussion note on inspiration progressed by one grade or more towards definitely dull [4]. The results of splenic percussion (positive versus negative) were compared with the results of Traube's space percussion, where a positive test was defined as uncertain, probably dull, or definitely dull.

After percussion, the patients were sequentially assigned to undergo either Middleton's maneuver or the combination of supine palpation followed by palpation in the right lateral decubitus position. On supine palpation, the spleen was palpated on deep inspiration while moving from the lower right quadrant upwards and medially to just below the left costal margin. The same patients were thereafter positioned in right lateral decubitus, and the examiners palpated from the right side of the bed in a similar fashion as described previously.

Middleton's maneuver was carried out in patients by having them place their left fist posteriorly and inferiorly to their left scapula [5]. Palpation was then carried out with the examiner positioned on the patient's left side with the fingers hooked under the left costal margin.

All palpation maneuvers were scored by each examiner on a five-point scale: 1 = spleen definitely not palpable, 2 = spleen probably not palpable, 3 = uncertain, 4 = spleen probably palpable, and 5 = spleen definitely palpable.

Patients examined by none of the study physicians, subjects whose diagnosis was known to the clinician, or patients who refused to participate were excluded from the analysis.

Ultrasound Classification

All ultrasound examinations were performed using Diasonic 400 DL machines equipped with a 3.5-MHz transducer. Real time sector scanning was performed on the patients, and a physician ultrasonographer (JDS) who was unaware of the initial interpretation and the results of the physical examination classified the spleens as enlarged or normal. Enlargement was defined in our study as a measured sonographic cephalocaudad diameter of greater than or equal to 13 cm [7,8].

Statistical Analysis

The unit of analysis was the patient examination, although these were not fully independent observations since most patients were examined by more than one observer.

Two-tailed t-tests were used for the comparison of continuous data, and chi-square tests for categoric variables [9]. The 95% confidence intervals (CI) for sensitivity and specificity were computed using the standard normal approximation of the binomial distribution [9]. The 95% CI limits of the likelihood

TABLE I

Clinical Characteristics of Patients with and Without Splenic Enlargement on Ultrasound

Characteristic	Normal Spleens (n = 75)	Enlarged Spleens (n = 43)	p Value
Mean age (years)	65.4 ± 15.4	57.7 ± 14.5	<0.01
Sex (female)	39 (52%)	17 (39.5%)	NS
Mean spleen size (cm)	10 ± 1.4	15.4 ± 2.2	<0.0001
Hematology ward	14 (19%)	12 (28%)	NS
Quetelet index (kg/m^2)	22.5 ± 5.6	23.1 ± 4.9	NS
Liver disease stigmata			
Total	21 (28%)	17 (39%)	NS
Ascites	17 (23%)	14 (33%)	NS
Jaundice	4 (5%)	7 (16%)	NS
Spider angiomata and telangiectasia	5 (7%)	10 (23%)	<0.05

ratio estimate were obtained using the log normal Taylor series approximation of the distribution of relative proportions [10].

Interobserver agreement was assessed using the kappa statistic with its 95% CI and by comparing pairs of examiners using a specific test threshold (definitely and probably not palpable versus uncertain, probably palpable, and definitely palpable).

We evaluated the sensitivity and specificity of each palpation maneuver for various score thresholds (i.e., for a cutoff of 1, the definitely not palpable findings were considered test-negative and all others were considered test-positive; for a cutoff of 2, definitely and probably not palpable findings were classified as negative and all others as positive, and so on).

Receiver operating characteristic (ROC) curves were generated for Traube's space percussion and all palpation maneuvers. The ability of a clinical maneuver to differentiate between the absence and presence of splenomegaly was assessed using ROC curve analysis [11]. An ROC curve displays the true-positive rate on the Y axis and the false-positive rate on the X axis, thus plotting the performance of a diagnostic test for varying test thresholds [12]. Using a modified maximum likelihood program, the area under the fitted curve [13] for each maneuver was compared with the area beneath the line of unity [14]. This 45° line represents a nondiscriminate test (area = 0.5) where the true-positive rate equals the false-positive rate. These comparisons were performed (where appropriate) with a matched or unmatched analysis.

RESULTS

Patient Population

Among the 180 patients eligible for entry, 62 (34%) were excluded due to early discharge, technically inadequate ultrasound examination results, splenectomy, death, and refusal to participate. Some of the remaining 118 patients were assessed by only one or two internists, yielding 245 patient examinations from a possible total of 354.

Patients could not take a deep breath because of pain in four instances, hence only 241 patient examinations were included in the splenic percussion sign analysis. Middleton's maneuver was carried out in 120 instances, and supine palpation in the other 125, of which 112 also had subsequent right lateral decubitus palpation (13 examinations could not be completed because the patients could not turn onto their right side due to pain, weakness, or a cumbersome wound dressing).

Forty-three of the 118 patients had an enlarged spleen accounting for 94 patient examinations (the cases), and 75 (64%) had "normal-sized" spleens resulting in 151 examinations (the controls) (**Table I**). The mean age for controls and cases was 65.4 ± 15.4 years versus 57.7 ± 14.5 years. Ultrasonographic measurements of the enlarged spleens ranged from 13 to 23 cm with a mean of 15.4 cm (± 2.2 cm). Normal-sized spleens measured between 7 and 12.5 cm, with a mean of 10 cm (± 1.4 cm).

The only significant differences in the clinical characteristics of patients with normal-sized spleens when compared with those with enlarged spleens were mean age (65.4 versus 57.7 years) and the presence of spider angiomata and telangiectasias (7% versus 23%) (Table I).

Performance of the Maneuvers

The discriminating ability of the splenic percussion sign was similar to that for Traube's space percussion [2]. The sensitivity and specificity of the splenic percussion sign were 79% and 46% compared with 62% and 72% for Traube's space percussion. The diagnostic accuracy of the splenic percussion sign (59%) was inferior ($p < 0.05$) to that of Traube's space percussion (68%), indicating that the splenic percussion sign was not a superior maneuver to Traube's space percussion.

The areas under the ROC curves for Middleton, supine, and right lateral decubitus palpation were respectively 0.73 ± 0.06, 0.79 ± 0.05, and 0.76 ± 0.06, indicating each maneuver was a significant discriminator alone for splenic enlargement ($p < 0.001$) but none was superior to the others (**Figure 1**).

Because of the randomized study design, and the above findings, the results of supine palpation and Middleton's maneuver were combined and analyzed as "palpation" (**Figure 2**). The area under the ROC curve for palpation was 0.76 ± 0.04 ($p < 0.0001$). The ROC curve for palpation lay above and to the left of the curve for Traube's space per-

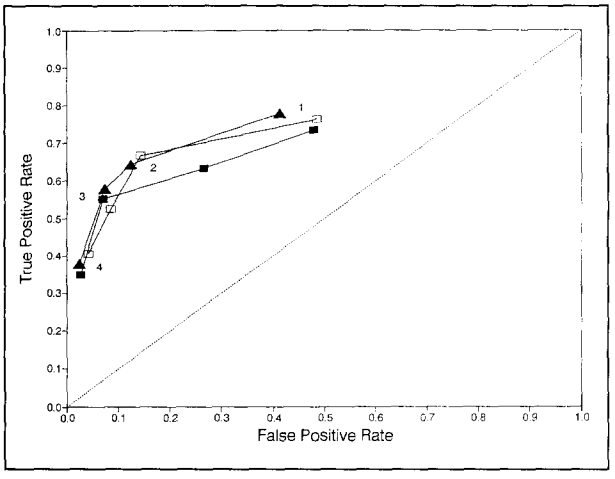

Figure 1. Receiver operating characteristic (ROC) curves for the individual palpation maneuvers. Every point of a given curve represents a palpation threshold for that maneuver. For example, for a cutoff of 1, definitely not palpable spleens were considered test-negative, and all other palpation findings were positive; for a cutoff of 2, all definitely or probably not palpable spleens were considered test-negative, and all others were positive, and so on. The areas under the ROC curves for Middleton (**solid squares**), supine (**triangles**), and right lateral decubitus (**open squares**) palpation were respectively 0.73 ± 0.06, 0.79 ± 0.05, and 0.76 ± 0.06, indicating each maneuver was a significant discriminator for splenic enlargement ($p < 0.001$). No one palpation maneuver was superior to another.

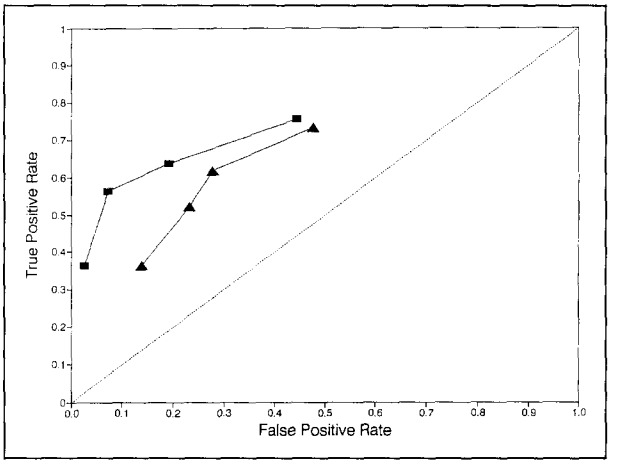

Figure 2. ROC curves for Traube's space percussion and palpation. The areas under the curves for Traube's space percussion (**triangles**) and palpation (**squares**) were 0.70 ± 0.04 and 0.76 ± 0.04 respectively, indicating each was a significant ($p < 0.005$) discriminator for splenic enlargement. Palpation was more specific than percussion at every test threshold, but this difference was not significant ($p = 0.14$).

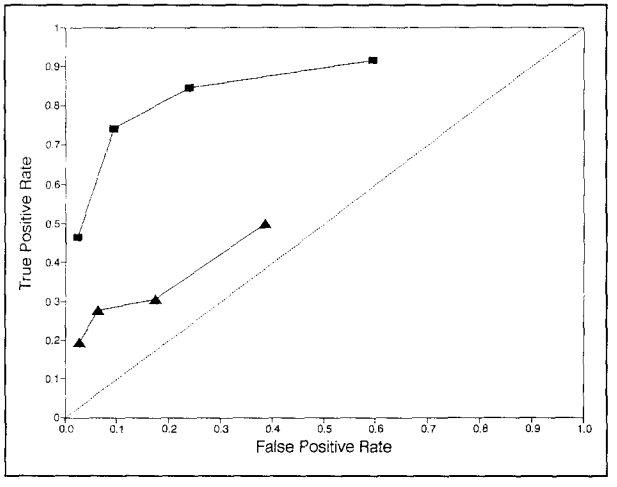

Figure 3. ROC curves for palpation according to the results of Traube's space percussion. The area (0.87 ± 0.04) under the ROC curve for palpation in patients with a positive percussion of Traube's space (definitely dull, probably dull, or uncertain) (**squares**) was significantly greater ($p < 0.0005$) than the area (0.55 ± 0.08) for those with negative percussion (**triangles**). Palpation among those with negative percussion was not a significant discriminator.

cussion, suggesting that palpation was a superior test with higher sensitivity and specificity. However, the areas under each curve were not significantly different ($p = 0.14$), although this comparison may have been limited by insufficient observations.

Of the 43 patients with enlarged spleens on ultrasound, 24 were assessed by Examiner 1 (TM), 31 by Examiner 2 (SAG), and 39 by Examiner 3 (LG). Positive palpation was noted in 54%, 61%, and 54% of patients respectively. Among the 75 patients with normal-sized spleens, 41, 46, and 64 were assessed by each of the three examiners and 98%, 89%, and 92% were identified as true-negatives respectively.

The interobserver kappa values obtained for palpation were 0.70 ± 0.14, 0.56 ± 0.19, and 0.57 ± 0.13, suggesting that the test reproducibility between examiners was good. Reproducibility was also better than that reported for Traube's space percussion [2]. Moreover, patients were examined at different times under varying circumstances, thereby potentially reducing the optimal agreement between examiners.

The mean splenic size among patients with positive percussion of Traube's space and positive palpation was 15.7 ± 2.9 cm, but was 11.6 ± 2.8 cm when palpation was negative. Splenic size among patients with negative percussion and positive palpation averaged 14.3 ± 3.8 cm. When both Traube's space percussion and palpation were negative, the mean splenic size was 10.8 ± 2.2 cm.

Palpation was a significantly better discriminator ($p < 0.0001$) among patients with percussion dullness (area = 0.87 ± 0.04) when compared with those with percussion tympany (area = 0.55 ± 0.08) (**Figure 3**). Moreover, after percussion tympany,

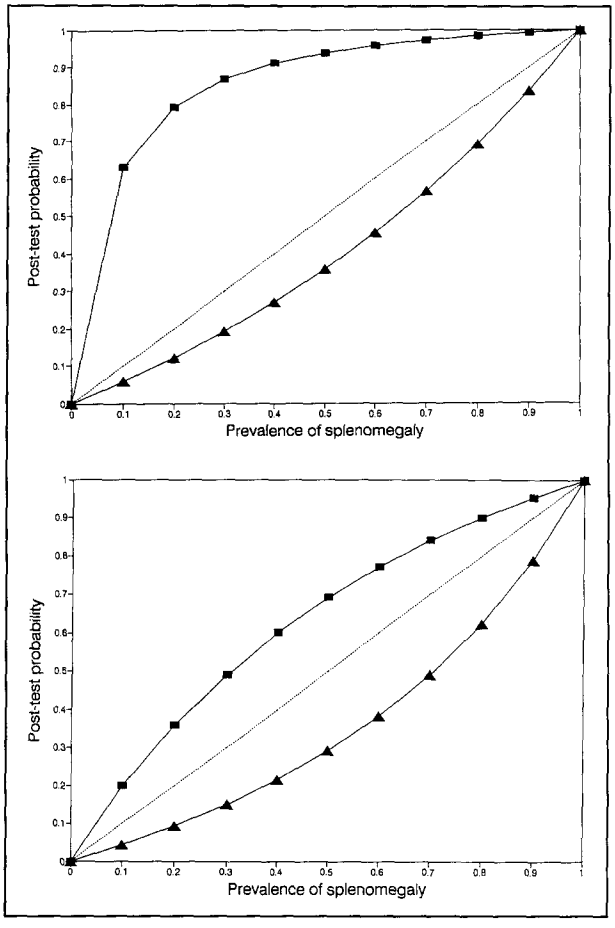

Figure 4. Top, post-test probability of splenomegaly after Traube's space percussion and palpation when both tests are positive (**squares**) or one or both tests are negative (**triangles**). The curve for positive concordant tests (**squares**) diverges further from the line of unity (**broken line**), indicating that positive concordant bedside maneuvers are most useful for ruling in splenomegaly. **Bottom,** post-test probability of splenomegaly after Traube's space percussion and palpation when one or both tests are positive (**squares**) or when both tests are negative (**triangles**). Both curves diverge only modestly from the line of unity (**broken line**), indicating limited utility in ruling in or ruling out splenomegaly with negative concordant maneuvers.

palpation performed no better than chance. The mean splenic sizes in these two groups were also significantly different (13.5 ± 3.49 cm versus 11.2 ± 2.67 cm respectively, $p < 0.0001$).

As previously described for Traube's space percussion [2], the performance of palpation was significantly better ($p < 0.01$) when carried out on the leaner patients in the study. Among those in the lower three quartiles of body mass (Quetelet index less than 25 kg/m^2), the area under the curve was 0.83 ± 0.04 compared with 0.65 ± 0.08 for heavier patients.

When a positive bedside examination was defined as Traube's space percussion-positive and palpation-positive (concordant-positive), the combined sensitivity was 46% and specificity 97%. When a positive bedside examination was defined as *either* maneuver being positive and a negative examination was defined as both maneuvers being negative (concordant-negative), the sensitivity rose to 72% and the specificity decreased to 68%. Using the combined test characteristics (as defined above) and Bayes' theorem, the post-test positive and negative probabilities of splenic enlargement were plotted for different pretest probabilities (prevalence) of splenomegaly (**Figure 4, top** and **bottom**). When both percussion and palpation were positive (concordant-positive), the post-test probability of splenic enlargement rose markedly and the corresponding curve diverged from the line of unity (where the pretest probability equals the post-test probability). When one or both tests were negative, the post-test probability did not substantially diverge from the line of unity, suggesting that concordant-positive maneuvers are most useful in ruling in splenomegaly (Figure 4, top). When a negative bedside examination was defined as both tests being negative (concordant-negative), the post-test probability of splenic enlargement after negative or positive bedside examinations diverged only modestly from the line of unity (Figure 4, bottom). This demonstrates that the maximum clinical utility of bedside examination occurs when percussion and palpation are both positive.

COMMENTS

Although attempts have been made to assess some bedside maneuvers objectively [15–24], the accuracy of the majority of physical examination techniques remains unstudied. We attempted to characterize the discriminating ability of commonly used physical examination maneuvers in the assessment of splenic enlargement to define an optimal sequence of percussion and palpation techniques. Previous comparative studies between radionuclide scanning and ultrasound have demonstrated close agreement in splenic volume estimations determined by the two methods [25].

The splenic percussion sign in our sample performed no better or no worse than Traube's space percussion. In addition, the splenic percussion sign takes longer to perform and cannot be carried out in some very ill patients. We therefore would recommend simple percussion of Traube's space.

All three palpation maneuvers appeared to be approximately equivalent in their ability to detect splenomegaly. Among 112 patient examinations, only one additional patient with an enlarged spleen was correctly identified by right lateral palpation when performed after supine palpation, while four

more patient examinations were incorrectly classified as positive. We would therefore not recommend the addition of right lateral palpation when supine palpation is available.

As previously reported for Traube's space percussion [2], the false-negative rate increased significantly when spleen palpation was performed in the heaviest patients in our study. For the palpation maneuvers, interobserver agreement was greater than that previously reported for Traube's space percussion [2] and may reflect the greater reproducibility of tactile sensation versus percussion.

Palpation was a better discriminator among patients with percussion dullness compared with those in whom Traube's space was tympanitic. However, as might be expected, characteristics like the mean splenic sizes in these two groups were significantly different. This suggests that percussion dullness identifies a subset of patients with enlarged spleens in whom palpation is most discriminating and supports the sequential use of both maneuvers. The optimal use of bedside maneuvers occurs when ruling in splenomegaly after both are positive (Figure 4, top).

Two retrospective studies previously reported that the physical examination of the spleen exhibited test sensitivities of 20% and 28%, and test specificities of 100% and 98%. These studies employed autopsy or nuclear medicine results as the gold standard [26,27]. Prospective analyses of palpation maneuvers have found test sensitivities varying between 54% and 59%, and test specificities of 69% to 100% [28–30]. Sullivan and Williams [4] reported on the performance of percussion (Nixon's maneuver [31] and the splenic percussion sign) and palpation maneuvers (supine and right lateral decubitus) while using nuclear medicine to define patients with splenomegaly. The combined palpations' sensitivity and specificity were 71% and 90%, similar to that reported in our study.

The bedside assessment of splenic enlargement will not obviate diagnostic imaging when such information is vital to further therapeutic management of the patient such as assessments for lymphoproliferative disorders. However, in other situations, the added diagnostic certainty that abdominal ultrasonography will bring to the clinician may not be as critical. The decision for further evaluation may be different for a healthy outpatient population with a low prevalence of splenomegaly [32] versus an inpatient population with a much higher prevalence (a pretest probability in part determined by the presence of other clinical clues acquired on history and coexisting physical signs). This pretest probability is paramount in affecting subsequent test-ordering decisions and is performed routinely by the clinician based on an intuitive process determined by personal and published experience [33].

We have defined the characteristics of bedside maneuvers most commonly used in the physical examination of the spleen and conclude that palpation is most useful when Traube's space percussion is positive. These two maneuvers are sufficient for an optimal bedside assessment of splenic enlargement. Similar data for other bedside maneuvers must be sought if we are to determine the optimal evaluation of patients when combining bedside techniques and other diagnostic tests.

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