Transillumination of hand tumors: a cadaver study to evaluate accuracy and intraobserver reliability

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Abstract

Background The aim of this study was to assess the accuracy and intraobserver reliability of the technique of penlight transillumination of simulated hand tumors as well as the rationale for the technique.

Methods Eight observers examined small (9.5 mm) plastic spheres in a fresh frozen cadaveric human hand 3 weeks apart in a blinded manner. The observers were divided into two overall groups based on their level of training. Four spheres simulating hand tumors (two dorsal and two palmar) were placed subcutaneously. The spheres were known to either transilluminate or to be opaque. The observers noted their impression as to whether the spheres either did or did not transilluminate. Accuracy and multi-rater-kappa-statistical analysis were performed.

Results The overall accuracy was 87.5%: 95% for senior group, 81% for junior group ($P=.388$, not significant). The average kappa of the intraobserver reliability overall was 0.46. The senior group had a kappa value of 0.67 (substantial agreement), the “junior” group: 0.25 (fair agreement).

Conclusions Accuracy at correctly determining whether or not a small hand tumor transilluminated was high. The senior group was more accurate overall in correctly determining transillumination, though not with statistical significance. Intraobserver reliability was high for the senior group and less robust for the junior group.

Keywords Transillumination · Hand tumor

Level of Evidence: I

Clinical relevance This study found that examiners are usually but not always correct in assessing the ability of a small hand mass to transilluminate. More senior observers were more consistent in their evaluations over a 3-week period than the junior group. Transillumination is a worthwhile physical examination technique that must be viewed in light of the clinical situation. This study is the first to objectively assess the accuracy and inter/intra-observer reliability with respect to transillumination of hand tumors. Nevertheless, there are many clinical variables that affect the ability of an examiner to determine whether a mass truly transilluminates or not. Some of these factors include the strength and width of the light source, thickness, and color of overlying skin, tumor size, and depth previous scars or edema in the vicinity, among others. Transillumination is one piece of information among many to be used by the clinician in assessing a soft tissue tumor of the hand.

Introduction

The medical technique of “transillumination” involves shining light, usually a penlight, through various body parts with the intention of differentiating between structures that readily transmit light, such as cystic tumors, and structures that do not easily transmit light, such as solid tumors. With respect to hand tumors, transillumination is used to distinguish between ganglion cysts and solid tumors, though certain solid tumors

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such as schwannomas and lipomas can conduct light in a manner similar to ganglion cysts. The literature supporting the technique of transillumination in the evaluation of hand tumors is extremely sparse with descriptions of the technique appearing mainly in anecdotal reports and textbook chapters [1–5]. Transillumination is inherently a subjective assessment and has not been scientifically studied with respect to clinician accuracy or intraobserver reliability. The goal of this study was to present observers with cadaveric hand masses known to either transilluminate or not to transilluminate, and to assess the accuracy and reliability of their observations concerning the ability of the masses to transilluminate with a penlight.

Materials and Methods

Eight observers (two Fellowship hand-trained orthopedic surgeons, two orthopedic surgeons, one physician in the first year of orthopedic residency training, and three fourth-year medical students) volunteered to participate in this study without the hope of financial reimbursement. All participants were familiar with the clinical technique of penlight transillumination of hand tumors. The four orthopedic surgeons were the “senior” group, and the remaining four observers were the “junior” group. A fresh frozen cadaveric human upper extremity (hand to elbow) was used for this study as the experimental model. Clear hollow plastic spheres (Small Parts INC., Miami, FL) measuring 9.5 mm in diameter were injected with either water or black India ink (Figs. 1 and 2). The water-filled spheres easily transilluminated, and the ink-filled spheres completely blocked light conduction (Figs. 1 and 2).

Two spheres were placed beneath the dorsal hand skin (one water-filled and one ink-filled) via a small longitudinal incision. The same individual placed all the spheres and was not involved in the assessment of the sphere’s ability to conduct light. One sphere was located on the radial side of

Fig. 2 Ink-filled sphere, opaque with penlight

the hand superficial to the first dorsal interosseous muscle and the other on the ulnar side of the hand superficial to the fourth dorsal interosseous muscle (Fig. 3). An identical set of spheres was inserted beneath the radial and dorsal palmar skin via a small longitudinal incision in the mid-palm. Therefore, the palmar and dorsal sides of the hand each had one sphere that transilluminated and one opaque sphere. Equal numbers of water and India ink spheres were employed.

A new standard pocket penlight (ADVA-Lite, Largo, FL) was used for this study. The observers were placed in a room simulating the conditions of a standard examining room with windows. The room lights were turned off, but there was still ambient daylight from the windows. In clinical practice, it is difficult to obtain complete darkness in an examining room, and we felt that this amount of ambient light best simulated our actual working environment. The observers were instructed to evaluate the spheres one at a time, sequentially, and to record their impression as to whether the spheres transilluminated or not. The observers were told that any or all of the spheres could

Fig. 1 Water-filled sphere, effect of transillumination with penlight

Fig. 3 Spheres placed subcutaneously on hand dorsum

either transilluminate or not (Figs. 4 and 5). The observers were not allowed to do a back-and-forth comparison between the spheres with the penlight to better simulate the clinical situation of evaluating a solitary hand tumor. The observations were repeated in exactly the same fashion 3 weeks later. The specimen was refrozen in between readings, and the same person reinserted the spheres in exactly the same place but in a reversed order; there was no difference in the visible appearance of the skin or specimen between readings. Accuracy and intraobserver reliability testing was then performed.

Statistical Methods

Multi-rater-kappa-statistical analysis was performed. The kappa value quantifies the extent to which the observed

$$\text{kappa} = \frac{[(\text{percent observed agreement}) - (\text{percent agreement expected by chance alone})]}{[100\% - (\text{percent expected by chance alone})]}$$

Kappas value will be between 1 and -1. kappa=1 means full agreement. Kappa=0 means no agreement. A negative value indicates less agreement than expected by chance.

For the interpretation, there are well-recognized values described by Landis and Koch and by Svanholm [6, 10]. We used the more precise interpretation of Landis and Koch:

A Kappa from 0.0 to .20 represents slight agreement, 0.21–0.40 fair agreement, 0.41–0.60 a moderate agreement, 0.61–0.80 a substantial agreement, and more than 0.81 an almost perfect agreement [6].

Simple one-way ANOVA testing was performed to determine significance comparing the accuracy of the “senior” to the “junior” group.

Statistical analysis was performed using the SAS® statistical package (SAS Institute Inc. Cary, NC).

Fig. 4 Sphere demonstrating transillumination with penlight

Fig. 5 Opaque sphere blocking penlight transillumination

agreement exceeds that which would be expected by chances alone.

Results

A total of 64 “sphere observations” were conducted. Fifty-six of the 64 observations were correct, resulting in an overall correct interpretation (accuracy) of 87.5% of the spheres. The “senior group” had an accuracy of 94%, and the “junior group” had an accuracy of 81%. This difference was not statistically significant ($p=0.388$). Four observers correctly interpreted all of the spheres at both the initial and the 3-week period (three “senior” and one “junior” observer).

The average kappa agreement of the intraobserver reliability overall was 0.46 which represented a moderate agreement. The senior group had an intraobserver kappa agreement of 0.67 which represented substantial agreement. The average kappa intraobserver reliability of the “junior” group was 0.25, which represents fair agreement.

Discussion

Transillumination of hand tumors or masses is a physical examination tool which ostensibly helps the examiner to distinguish between solid and cystic lesions.

The premise of transillumination is that cystic lesions transilluminate while solid tumors do not. This premise may be faulty in that some fluid-filled masses may not transilluminate (such as an India-ink filled sphere or opaque blood-filled cyst) and conversely, some solid masses, such as benign nerve sheath tumors and lipomas, may appear to transilluminate [7–9].

The ability of examiners to assess the property of a hand mass to transilluminate has not been studied in a scientific manner. Variables which might affect the subjective determination of transillumination include the thickness of the overlying skin, the mobility of the lesion, the power of the optical source, the experience of the examiner, and the amount of ambient light in the room. We tried to control for these factors in this study as best as possible and devised a model consisting of a known transilluminating sphere and a known opaque sphere, representing the ideal extreme of each end of the “transilluminating spectrum.”

In this study, the overall accuracy of the observers was relatively high in correctly determining whether the spheres transilluminated or not. The intraobserver reliability was high for the senior group and less robust for the junior group. The senior group was more accurate than the junior group in correctly determining transillumination, though this did not reach the level of statistical significance. The importance of the higher intraobserver reliability noted in the senior group is most likely attributable to greater clinical experience.

We intentionally selected an approximately 1 cm sphere as the “tumor” size for this study, after testing larger spheres of 2 or 3 cm diameter. The larger spheres were always readily identified as transilluminating or not in our model, leading us to employ the smaller size sphere to test the acumen of the clinicians in this study. The 1-cm sphere size is clinically applicable to a typical hand or finger tumor, such as a retinacular ganglion cyst or small giant cell tumor of tendon sheath. The commonly seen 2-cm diameter dorsal ganglion cyst, being a larger size, should theoretically transilluminate more strikingly in clinical practice than the smaller hand tumors. While 1-cm diameter spheres were used in this study, it is possible that using larger 2-cm spheres could result in better accuracy and inter/intraobserver reliability.

The role of transillumination in clinical practice has never been subjected to rigorous examination. In fact, the literature on transillumination of hand tumors, aside from passing references in textbook chapters, is virtually nonexistent. Many clinicians and hand surgeons carry a penlight and use it during physical examination in the evaluation of masses, though there are no statistics concerning the prevalence of this physical examination modality. MRI and ultrasound are two imaging modalities which can also aid in the differentiation between cystic and solid structures, though at a much higher cost than a penlight which can function well for months on two AAA batteries. Hand tumors in a typical location for a ganglion cyst that transilluminate will usually, but not always, indicate a diagnosis of ganglion cyst. Aspiration of a suspected ganglion cyst should yield typical ganglion type fluid and confirm the diagnosis. The inability to aspirate the usual fluid from a suspected ganglion cyst should prompt concern that a solid lesion is present which should then prompt consideration of incisional or excisional biopsy to

yield a definitive diagnosis. Needle aspiration of small hand tumors is a relatively painless and inexpensive way to confirm the presence or absence of a ganglion cyst, and the authors routinely recommend needle aspiration as an adjunct to transillumination. In children, needle aspiration of suspected ganglion cysts is rarely performed in the office. In this pediatric population, transillumination combined with ultrasound examination and X-ray can help distinguish between a volar ganglion cyst vs a cartilaginous tumor, for example.

This study found that examiners are usually but not always correct in assessing the ability of a small hand mass to transilluminate and that more experienced clinicians tended to be more consistent in their interpretation of transillumination between the two points in time used in this investigation, as might be expected. Transillumination is a worthwhile clinical tool, but the information provided must be interpreted in light of the totality of the clinical scenario.

This study is the first to objectively assess the accuracy and inter/intraobserver reliability with respect to transillumination of hand tumors. Nevertheless, there are many clinical variables that affect the ability of an examiner to determine whether a mass truly transilluminates or not. Some of these factors include the strength and width of the light source, thickness and color of overlying skin, tumor size, and depth previous scars or edema in the vicinity, among others. Transillumination is one piece of information among many to be used by the clinician in assessing a soft tissue tumor of the hand.

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