Original Article

Ultrasound of Focal Lesions of the Hand and Wrist: Accuracy, Validity, and Factors Determining Treatment Decision

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Objective: To estimate the accuracy and validity of ultrasound in evaluating focal lesions of the hand and wrist and determine the factors affecting the treatment.

Materials and Methods: Eighty focal lesions were enrolled and divided into two groups (surgical and non-surgical group). The lesions in each group were subclassified as cystic, solid, vascular, and inflammation or infectious lesion, using either pathological, or ultrasound diagnosis as the reference.

Results: The accuracy of ultrasound was low at 57%, 54%, 29%, and 25% for cystic, solid, vascular lesion, and inflammatory or infectious lesion, respectively. There was no significant difference between the ultrasound and clinical diagnosis for hand and wrist lesions (*p*-value 0.8793). Based on pathological findings, all lesions in the study were benign. The factors that were found to influence treatment (surgical versus non-surgical) in the present study relied on the ultrasound findings and size of the lesion. The ultrasound report of cyst or inflammatory or infectious tended to be followed by conservative treatment (73% and 90%, respectively). On the other hand, surgical treatment was performed if the ultrasound reports resulted as solid or vascular lesion (60% and 67%, respectively) or regarding to the larger size as well (2.5±1.8 cm in surgical versus 1.5±1.1 cm in non-surgical group).

Conclusion: The accuracy of ultrasound evaluation of focal lesions in the hand and wrist is low (25% to 57%). However, the lesions with larger size or the solid and vascular lesions had more tendency to undergo surgery. Therefore, ultrasound may help suggesting the therapeutic decision.

Keywords: Ultrasound, Hand and wrist, Focal lesion, Accuracy, Treatment

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Focal lesions of hand and wrist are frequently encountered in clinical practice, and the most common are ganglion cysts[1,2]. However, solid masses are also often found such as giant cell tumor of tendon sheath [GCTTS] or the so-called "localized tenosynovial giant cell tumor"[3], lipoma, and hemangioma[1,4]. Malignant lesions of this region are quite rare, approximately 4% of sarcoma among upper extremity[5], which frequently are malignant fibrous histiocytoma (or undifferentiated pleomorphic sarcoma according to WHO 2013 classification[3]) and epithelioid sarcoma[5].

The treatment options are different between benign and malignant entities. Some specific benign lesions may be managed conservatively by observation without any surgical intervention[6] whereas sarcomatous lesions need adequate surgery to prevent residual tumor or local recurrence[7]. The precise diagnosis required for the best therapeutic outcome and imaging is frequently obligated to characterize the manner of the lesion[8,9]. Among the imaging modalities, magnetic resonance imaging [MRI] is the best modality for precise diagnosis of soft tissue lesions[8]. However, it has some limitations including high expenditure, long schedule appointment in some institutions, lack of availability, and certain patients' conditions as well.

Ultrasound is well known for many advantages including excellence of confirmation for the presence of a lesion and distinguishing cystic from solid masses[10,11], widely available, low expenditure, easier to use in practical situations, and free from the ionizing radiation exposure. Although several studies have shown the high accuracy of the ultrasound for assessment focal masses[11-13], some authors reported low accuracy[14] and might lack of effective discrimination between solid and cystic lesions with gray-scale ultrasound[15,16].

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To our knowledge, there is no study for the impact of ultrasound in evaluating focal lesions of hand and wrist to influence clinical judgement. Thus, the primary objective of the present study was to estimate the accuracy and confirm the validity of ultrasound to assess focal lesions of the hand and wrist by classifying them as cysts, solids, vascular lesions and inflammation or infection using pathological findings as the reference standard. The secondary objective was to evaluate the impact of sonographic results to management decision (surgical versus non-surgical).

Materials and Methods

Patients

Institutional review board approval was obtained from our hospital ethics committee. A database search and review of sonographic reports and medical records were performed in patients who underwent ultrasound to evaluate focal lesions of the hand and wrist between June 2009 and May 2015. Patients who did not have official sonographic reports, medical record data, or lost follow-up were excluded from the study. The medical records were reviewed for histologic findings in all patients with pathologically-proven lesions, or reviewed for further management in non-surgical patients including conservative treatment, further imaging investigation and follow-up within six months after undergoing diagnostic ultrasound.

Sonographic examination and image interpretation

Ultrasound studies were performed by board-certified radiologists as a part of routine patient care during the study period, using high-frequency linear-array transducers at frequencies ranging from 5 to 15 MHz with varying imaging planes to determine the lesions. Power and or color Doppler imaging was routinely obtained to demonstrate vascularity within and around the lesions.

According to pathological reports, the patients who underwent surgical treatment were classified into four groups (cyst, solid, vascular, and inflammatory or infectious lesions). In non-surgical group, the patients were categorized in a similar way into five groups (cyst, solid, vascular, inflammatory or infectious, or non-detectable lesion) according to the sonographic diagnosis.

Regarding the sonographic diagnosis, if any case had more than one differential diagnosis in the report, the first-ordered in the differential diagnosis was assumed to be the principal diagnosis and was used for analysis.

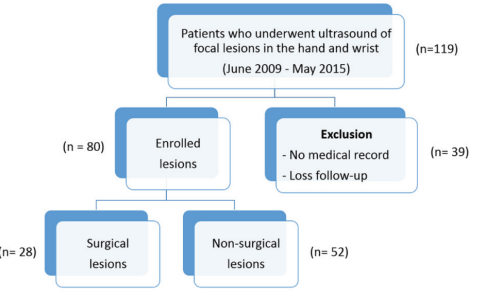

Figure 1. Sequential diagram illustrating the inclusion and exclusion methodology.

Statistical analysis

Descriptive statistics for baseline demographic data (sex, anatomical locations, pathology) were calculated for each group. Continuous variables (age, size) were presented as mean ± standard deviation [SD]. Quantitative statistical analysis was performed as follow; accuracy, sensitivity, specificity, positive/negative likelihood ratio, positive/negative predictive value, and receiver operating characteristic [ROC] area with 95% confidence interval. The data were calculated by using Stata v.14 statistical software (StataCorp, College Station, Texas, USA).

Results

The 119 focal lesions of the hand and wrist from 110 patients received ultrasound evaluation between June 2009 and May 2015. Thirty-nine lesions were excluded because of the lack of medical records or loss of follow-up. Eighty lesions were enrolled in the present study. Among these 80 lesions, 28 lesions underwent surgery with pathological records, while the other 52 lesions were treated conservatively (Figure 1).

Demographic data for the surgical group (n = 28) are shown in Table 1, which categorized the lesions into four groups using pathological reports as the reference. All of these lesions were benign. The lesions were found about the wrist joint rather than in the hand and finger areas (75% vs. 25%). The cystic and vascular lesions were more common in female patients, whereas solid lesions were more frequent among male patients. The most common lesions were ganglion cyst (39%) followed by solid mass (36%), vascular lesion (18%) and inflammatory or infectious lesion (7%), respectively. The mean age group of vascular lesion (50.8±18.5 years) was slightly higher than other lesions.

Demographic data for the non-surgical group (n =

52) are shown in Table 2, which classified the lesions into five groups by sonographic findings. The lesions are similarly detectable about the wrist joint rather than in the hand and finger regions (69% vs. 31%). The most common lesions were cyst (58%), which were similarly more common among female patients (80%), the majority of whom were on volar aspect of right wrist.

Statistical analysis of the surgical group (n = 28) is shown in Table 3, including accuracy, sensitivity, specificity, positive and negative likelihood ratio, positive and negative predictive value, and ROC area with 95% confidence interval based on the sonographic diagnosis using pathological findings as the reference standard. The accuracy of sonographic diagnosis is low at 57%, 54%, 29%, and 25% for cyst, solid, vascular, and inflammatory or infectious lesions, respectively. The sensitivity is high for the cyst (81.8%) and solid lesion (80%), whereas the specificity is low (26.1% to 41.2%) in all groups. The data analysis of the

Table 1. Demographic data for the surgical group (n = 28), categorized by pathology

Parameter	Cyst	Solid	Vascular	Inflammation/infection	Total
No. of lesions	11 (39%)	10 (36%)	5 (18%)	2 (7%)	28 (100%)
Sex					
Male	4	7	0	1	12 (43%)
Female	7	3	5	1	16 (57%)
Age (years)	38.1±16.2 (13 to 63)	36.9±15.7 (3 to 53)	50.8±18.5 (27 to 64)	37.4±51.8 (0.75 to 74)	39.8±18.7 (0.75 to 74)
Site					
Right	6	5	4	2	17 (61%)
Left	5	5	1	0	11 (39%)
Location					
Finger	0	0	1	0	1 (4%)
Hand	2	3	1	0	6 (21%)
Wrist	9	7	3	2	21 (75%)
Part					
Dorsal	5	2	2	2	11 (39%)
Volar	6	8	3	0	17 (61%)
Size (cm)	2.1±1.8 (0.4 to 7.1)	2.6±1.3 (1 to 4.6)	2.1±1.9 (0.5 to 4.4)	5.3±2.5 (3.5 to 7)	2.5±1.8 (0.4 to 7.1)
Pathology	Ganglion cyst, 11 (39%)	Lipoma, 5 (18%) Schwannoma, 2 (7%) Fibrous tumor, 3 (10.5%)	AVM, 2 (7%) Hemangioma, 1 (3.5%) Angioma, 1 (3.5%) Thrombus, 1 (3.5%)	Calcium pyrophosphate deposition disease, 1 (3.5%) Fibroblastic proliferation, 1 (3.5%)	

Table 2. Demographic data in non-surgical group (n = 52), classified by sonographic diagnosis

Parameter	Cyst	Solid	Vascular	Inflammation/ infection	No lesion	Total
No. of lesions	30 (58%)	8 (15%)	2 (4%)	9 (17%)	3 (6%)	52 (100%)
Sex						
Male	6	1	1	4	1	13 (25%)
Female	24	7	1	5	2	39 (75%)
Age (years)	36.0±17.3 (1 to 83)	58.0±9.3 (49 to 70)	9.0±9.9 (2 to 16)	66.2±15.4 (38 to 79)	59±31.2 (30 to 92)	45.0±21.8 (1 to 92)
Site						
Right	17	3	1	6	1	28 (54%)
Left	13	5	1	3	2	24 (46%)
Location						
Finger	0	1	0	1	0	2 (4%)
Hand	8	4	1	1	0	14 (27%)
Wrist	22	3	1	7	3	36 (69%)
Part						
Dorsal	12	3	1	4	1	21 (40%)
Volar	18	5	1	5	2	31 (60%)
Size (cm)	1.5±1.2 (0.4 to 2.9)	0.96±0.4 (0.7 to 1.6) *3 lesions; N/A	2±0.6 (1.6 to 2.4)	2.0±1.9 (0.2 to 3.9) *6 lesions; N/A	N/A	1.5±1.1 (0.2 to 3.9) *12 lesions; N/A

N/A = not available

Table 3. Sonographic diagnosis of focal lesions in the hand and wrist, using pathology as reference standard

Pathology	Accuracy (%)	Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	LR(+) (95% CI)	LR(-) (95% CI)	PPV (95% CI)	NPV (95% CI)	ROC area
Cyst	57	81.8 (48.2 to 97.7)	41.2 (18.4 to 67.1)	1.39 (0.856 to 2.26)	0.442 (0.111 to 1.75)	47.4 (24.4 to 71.1)	77.8 (40 to 97.2)	0.615 (0.445 to 0.785)
Solid	54	80 (44.4 to 97.5)	38.9 (17.3 to 64.3)	1.31 (0.809 to 2.12)	0.514 (0.131 to 2.02)	42.1 (20.3 to 66.5)	77.8 (40 to 97.2)	0.594 (0.42 to 0.769)
Vascular	29	40 (5.27 to 85.3)	26.1 (10.2 to 48.4)	0.541 (0.18 to 1.63)	2.3 (0.852 to 6.21)	10.5 (1.3 to 33.1)	66.7 (29.9 to 92.5)	0.33 (0.073 to 0.587)
Inflammation/ infection	25	0 (0 to 84.2)	26.9 (11.6 to 47.8)	0	3.71 (1.97 to 7)	0 (0 to 17.6)	77.8 (40 to 97.2)	0.135 (0.048 to 0.222)

CI = confidence interval; LR(+) = positive likelihood ratio; LR(-) = negative likelihood ratio; PPV = positive predictive value; NPV = negative predictive value; ROC = receiver operating characteristic

Table 4. Clinical diagnosis of focal lesions in hand and wrist, using pathology as reference standard

Pathology	Accuracy (%)	Sensitivity (%) (95% CI)	Specificity (%) (95% CI)	LR (+) (95% CI)	LR (-) (95% CI)	PPV (95% CI)	NPV (95% CI)	ROC area
Cyst	46	90.9 (58.7 to 99.8)	17.6 (3.8 to 43.4)	1.1 (0.827 to 1.47)	0.515 (0.0611 to 4.34)	41.7 (22.1 to 63.4)	75 (19.4 to 99.4)	0.543 (0.414 to 0.672)
Non-cyst	54	82.4 (56.6 to 96.2)	9.09 (0.23 to 41.3)	0.906 (0.679 to 1.21)	1.94 (0.23 to 16.4)	58.3 (36.6 to 77.9)	25 (0.631 to 80.6)	0.457 (0.328 to 0.586)

CI = confidence interval; LR(+) = positive likelihood ratio; LR(-) = negative likelihood ratio; PPV = positive predictive value; NPV = negative predictive value; ROC = receiver operating characteristic

surgical group (n = 28), based on clinical diagnosis using pathology as the reference standard are shown in Table 4. The accuracy of clinical diagnosis is low at 46% and 54% for cyst and non-cyst lesion, respectively. The sensitivity is high in both groups (90.9% in cyst and 82.4% in non-cyst lesions), whereas the specificity is low (9.1% to 17.6%) in both groups. Comparison of the statistical values in the surgical group (n = 28) between sonographic diagnosis and clinical diagnosis is shown in Table 5. The results show no significant difference in accuracy, sensitivity, and specificity between sonographic and clinical diagnosis of focal lesions in the hand and wrist (*p*-value 0.8793).

In Table 6, we divided the lesions into two groups (surgical vs. non-surgical) according to the sonographic diagnosis. The results illustrate that if the sonographic report is cyst or inflammatory/infectious lesion, treatment will favor non-surgery (73% in cysts and 90% in inflammatory/infectious lesions). In contrast, the treatment had a tendency to be surgery when ultrasound reported a solid or vascular lesion.

With regard to pathological findings, incorrect ultrasound diagnoses were reviewed in all groups as described in Table 7.

Table 5. Accuracy, sensitivity, specificity, and ROC curve for cyst and non-cyst between the sonographic and clinical diagnosis, using pathology as the reference standard

Parameter	Sonographic diagnosis	Clinical diagnosis
Accuracy (%)	86	86
Sensitivity (%) (95% CI)	81.8 (48.2 to 97.7)	90.9 (58.7 to 99.8)
Specificity (%) (95% CI)	88.2 (63.6 to 98.5)	82.4 (56.6 to 96.2)
ROC curve	0.85 (0.70 to 0.99)	0.86 (0.73 to 0.99)

CI = confidence interval; ROC = receiver operating characteristic

Table 6. Based on sonographic diagnosis (n = 80): lesions were classified into surgical and non-surgical groups

Ultrasound diagnosis	Surgical group, n (%)	Non-surgical group, n (%)	Total, n (%)
Cyst	11 (27)	30 (73)	41 (100)
Solid	12 (60)	8 (40)	20 (100)
Vascular	4 (67)	2 (33)	6 (100)
Inflammation/infection	1 (10)	9 (90)	10 (100)
No lesion	-	3 (100)	3 (100)
Total	28 (35)	52 (65)	80 (100)

Discussion

In the present study, the accuracy of sonographic assessment of focal lesions about the hand and wrist is low at 57%, 54%, 29%, and 25% for cyst, solid, vascular, and inflammatory or infectious lesions, respectively. Although several studies[11-13,17] have shown high accuracy for sonographic assessment (69% to 100%), our result corresponds to the study by Höglund et al[14], which reported the accuracy of ultrasound at 51%. Lee et al[18] found 23 solid tumors that were misdiagnosed as cystic lesions among 430 lesions on sonographic study. The result of low accuracy in the present study could be attributed to the small sample size (n = 28), selection bias (one

Table 7. Based on sonographic diagnoses: pathological findings in the surgical group.

Ultrasound diagnosis	n (%)	Pathologic findings (No. of lesions)
Cyst	11 (27)	Ganglion cyst (9) Lipoma (1) Arteriovenous malformation (1)
Solid	12 (60)	Lipoma (5) Schwannoma (2) Fibrous tumor (1) Ganglion cyst (1) Arteriovenous malformation (1) Hemangioma (1) Calcium pyrophosphate deposition disease (1)
Vascular	4 (67)	Thrombus (1) Angioma (1) Fibrous tumor (1) Reparation process (1)
Inflammation/infection	1 (10)	Ganglion cyst (1)

tertiary referral center consists of many specialists with high experience, the classical cases were therefore, diagnosed and treated without further investigation, only the more difficult cases were sent for sonographic evaluation), as well as choosing the first-ordered differential diagnosis for analysis.

Regarding pathological findings as reference, the present study has shown no significant difference between sonographic and clinical diagnosis for the hand and wrist lesions. Aaken et al[19] reported no significant difference to diagnose cyst between the sonographic and clinical diagnosis. However, other studies[11,13] show greater accuracy for sonographic evaluation. This may presumably be explained by the clinical diagnosis that was made by specialist physicians, and they may make the diagnosis with certain special tests (i.e., light trans-illumination test), resulting in increased accuracy of the clinical diagnosis.

All lesions in the present study are benign, corresponding with the prior study that showed about 98% of benign lesions (including tumor and tumor-like lesions)[4]. The present study also illustrated that ganglion cyst is the most common benign lesion in hand and wrist, which is more common in woman, in accordance with the literatures[1,11,20]. Malignant neoplasm was not observed in the present study. This could be due to the rare prevalence of malignancy in the hand and wrist, along with the small sample size in the present study.

The factors that were found to influence treatment decision (surgical versus non-surgical) in the present study was the types of lesion (cyst, solid, vascular and inflammatory or infectious lesion) and the size of lesion. If the sonographic analysis reported a cyst or inflammatory/infectious lesion, the management would tend to be non-surgical (73% in cyst and 90% in inflammatory or infectious lesion). On the other hand, the treatment would move forward to the surgical intervention if the sonographic examination reported a solid or vascular lesion (60% in solid and 67% in vascular lesion). In addition, the larger size lesions have a tendency to undergo surgery (2.5±1.8 cm in the surgical group versus 1.5±1.1 cm in the non-surgical group).

There were three suspected focal lesions by physical examination, the first was not detectable on sonographic examination, the second was shown to be an osseous prominence, and the third appeared as prominent vessel on ultrasound. This suggested that normal variations can mimic neoplasms regarding to physical examination. With reference to pathological report, sonographic examination can diagnose cyst nine from 11 lesions (ganglion cyst). The remaining two lesions interpreted as cyst on sonographic study were proved to be lipoma and arteriovenous malformation by histology. Ultrasound incorrectly diagnosed four of 12 solid lesions (one each of ganglion cyst, arteriovenous malformation, hemangioma, and calcium pyrophosphate deposition disease), two of four vascular lesions (one each of fibrous tumor and reparative process), and one lesion misinterpreted as inflammatory or infectious lesion had turned out to be a ganglion cyst. This may suggest a limitation of sonographic evaluation in that solid and cystic lesions may have rather similar appearance.

There were some limitations to the present study. The first was the small numbers of cases with pathologically approved (n = 28). The second could be characterized by selection bias involving only single academic tertiary care center. The last was favored the first-ordered differential diagnosis for experiment.

Conclusion

The accuracy of sonographic assessment for focal lesions in the hand and wrist is low (25% to 57%) and there is no statistically significant difference between sonographic and clinical diagnosis. Size and sonographic features of the lesions act on the management decision. Lesions with larger size, or with sonographic analysis as solid or vascular lesions are subjected to undergo surgery, whereas smaller lesions or those sonographically interpreted as cyst or inflammatory or infection tended to encounter conservative treatment. Aside from many advantages of ultrasound including low cost, practically feasible, and

no radiation hazard, it is valuable to verify existence of the lesion and to distinguish between cystic and solid lesions, all of which aid in recommendation for the proper management.

What is already known on this topic?

The most common lesion among focal lesions in hand and wrist is ganglion cyst. Several studies have shown high accuracy for sonographic assessment (69% to 100%) in evaluation of focal lesions of hand and wrist.

What this study adds?

Prevalence of disease entities among the focal mass in Thai population. The accuracy of ultrasound evaluation of focal lesions in the hand and wrist in Thailand is variable among the institutes, in our study is low (25% to 57%). Ultrasound help suggest the therapeutic decision for the focal lesion of hand and wrist, which the lesions with larger size and interpreted as solid and vascular lesions had more tendency to undergo surgery.

Potential conflicts of interest

The authors declare no conflict of interest.

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