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CLINICAL INVESTIGATION NON-VASCULAR INTERVENTIONS

Assessing the Need for Preprocedural Laboratory Tests and Stopping Non-steroidal Anti-inflammatory Drugs/Aspirin in Patients Undergoing Percutaneous Bone and Soft Tissue Biopsies

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Abstract

Purpose Although image-guided biopsies of bone and soft tissue lesions have a low complication rate, there is limited data evaluating use of preprocedural laboratory tests. To address this issue, patients were not required to stop non-steroidal antiinflammatory drugs (NSAIDs) and aspirin or to obtain preprocedural laboratory tests [complete blood count (CBC) and international normalized ratio (INR)], except in special circumstances. The bleeding complication rate, rate of same day biopsies, and the time from when the biopsy was ordered to when it was performed were obtained.

Materials and Methods A total of 332 patients who underwent bone or soft tissue biopsies performed at our institution between 9/1/2017 and 1/9/2019 were prospectively analyzed. These data were compared to a retrospective biopsy cohort of 323 patients between 7/1/2015 and 7/1/2017. Data collected included method of image guidance and bleeding complication rate. The number of days from ordering to performing a biopsy and number of same day biopsies were recorded.

Results There were no bleeding complications in either cohort (OR 1.00, $P = 1$). The mean time from ordering to performing a bone biopsy was significantly decreased in the prospective group (6.6 days) compared to the retrospective group (8.1 days) ($P = 0.012$). There were more same day biopsies in the prospective cohort (11.4% vs. 3.4%) ($P < 0.001$).

Conclusions Preprocedural CBC and INR for bone and soft tissue biopsies can be safely eliminated in most patients. Biopsies performed while patients are taking NSAIDs/aspirin can safely be performed. Adopting revised preprocedural laboratory criteria can result in decreased time to completion of biopsies.

Keywords Biopsy · MSK · INR · CBC · Laboratory test · Bleeding

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Introduction

The number of image-guided procedures used to obtain tissue diagnosis performed has continually increased over the past 40 years [1–3]. Many studies have shown that these image-guided procedures have a low complication

rate [4–8]; however, there is limited data about which preprocedural laboratory tests (coagulation tests, platelet count, and hematocrit) should be required for each patient [9–12]. It is important to identify the optimal preprocedural laboratory tests required for patients undergoing image-guided percutaneous biopsies of bone and soft tissue lesions because excessive testing may incur additional cost to the patient and potentially delay the procedure [13], and because inadequate testing may result in increased bleeding complication rates. All patients at our institution undergoing superficial image-guided aspirations or biopsies underwent a preprocedural complete blood count (CBC), which includes the platelet count, and International Normalized Ratio (INR) tests between 7/1/2015 and 7/1/2017. In addition, prior to July 2017, patients were asked to stop non-steroid anti-inflammatory drugs (NSAIDs) and/or aspirin (81 mg and 325 mg) for 5 days prior to the procedure to reduce the bleeding complication rate.

As a quality improvement initiative at our institution, patients were no longer required to undergo routine CBC and INR laboratory tests prior to a routine image-guided bone and soft tissue biopsy procedures of the extremities (Society for Interventional Radiology (SIR) category 1) and spine/chest wall (SIR category 2). For a select few, the indications for laboratory testing included patients with known liver dysfunction, bleeding disorders, or on heparin/warfarin/enoxaparin. Patients could continue taking preprocedural NSAIDs and aspirin. Clopidogrel and warfarin were not given to the patient for 5 days prior to their scheduled biopsy date. INR was only tested in patients on warfarin. These patients were prospectively followed to assess whether preprocedural CBC and INR tests and stopping aspirin/NSAIDs were necessary and influenced complication rates.

The authors hypothesize that preprocedural laboratory tests are often superfluous in most patients and often delays time to biopsy. The aim of this study was thus twofold: first, to evaluate if eliminating preprocedural laboratory tests (consisting of CBC and INR), except for select patients, and eliminating stopping NSAIDs/aspirin, resulted in an increase bleeding complication rate in patients undergoing routine image-guided bone and soft tissue biopsies, and second, to evaluate if this change decreased the time from when the biopsy was ordered to when the biopsy was performed.

Materials and Methods

This study was approved by the local Institutional Review Board and was compliant with the Health Insurance Portability and Accountability Act (HIPAA), and the need for signed informed consent was waived. Patients included in this study were patients with non-intra-abdominal flank lesions, non-intra-thoracic chest wall lesions, superficial soft tissue and bone lesions of the extremities and one spine lesion that required biopsy for diagnosis or research purposes. Patients that could not physically undergo image-guided biopsy (i.e., large body habitus, claustrophobia) were excluded from this study. In all cases, biopsies were performed by one of seven fellowship-trained musculoskeletal (MSK) radiologists [3–9 years' experience] with the assistance of one of ten MSK radiology fellows.

Prior to restricting laboratory testing, the workflow in scheduling a biopsy is shown in Fig. 1. In the prospective arm of the study, the order would be placed by the clinician to be approved by an MSK radiologist, and then scheduled for biopsy (Fig. 1).

Biopsies were performed using computed tomography guidance (CT) or ultrasound guidance. Bone biopsies were performed using a co-axial biopsy device (12/13 Gauge (G) or 14/15 G) (Bonopty, AprioMed, Uppsala, Sweden). Soft tissue biopsies were performed using a co-axial Bard device (14G-20G) (CR Bard, Murray Hill, New Jersey) or a Temno device (18-20G) (Beckton Dickinson, Franklin Lakes, New Jersey). Fine needle aspirations (FNAs) were performed using either a Westcott (Argon Medical Devices, Frisco, TX, USA) or Chiba (Argon Medical Devices, Frisco, TX, USA) 20, 22, or 25 G needle. Imaging documentation of proper needle placement through the lesion was obtained in all patients. Patients undergoing CT-guided bone or soft tissue biopsies were given moderate sedation with midazolam and fentanyl in addition to local anesthesia (Lidocaine/Bupivacaine). Patients undergoing ultrasound-guided biopsies were given local anesthesia (Lidocaine 1%/Bupivacaine 0.25–0.5%). Patients who received midazolam and fentanyl were monitored for at least 1 h after the last dose was given per institution protocol.

Bleeding Complication Rate

Three hundred and thirty-two (332) patients who underwent bone and soft tissue biopsies (210 bone and 122 soft tissue biopsies) performed at our institution from 9/1/2017 to 1/9/2019 were prospectively analyzed. Out of the combined 332 patients in the prospective cohort, 8 patients either on anticoagulants (5/8), personal history or family history of bleeding/inherited bleeding disorders and noticed easy bruising/bleeding (1/8), or with chronic liver disease/cirrhosis (2/8) were required to obtain preprocedural CBC and INR. The remaining 324 patients did not undergo preprocedural CBC and INR laboratory tests.

A retrospective review of 323 (184 image-guided bone and 139 image-guided soft tissue) biopsies performed by our institution between 7/1/2015 and 7/1/2017 was used as

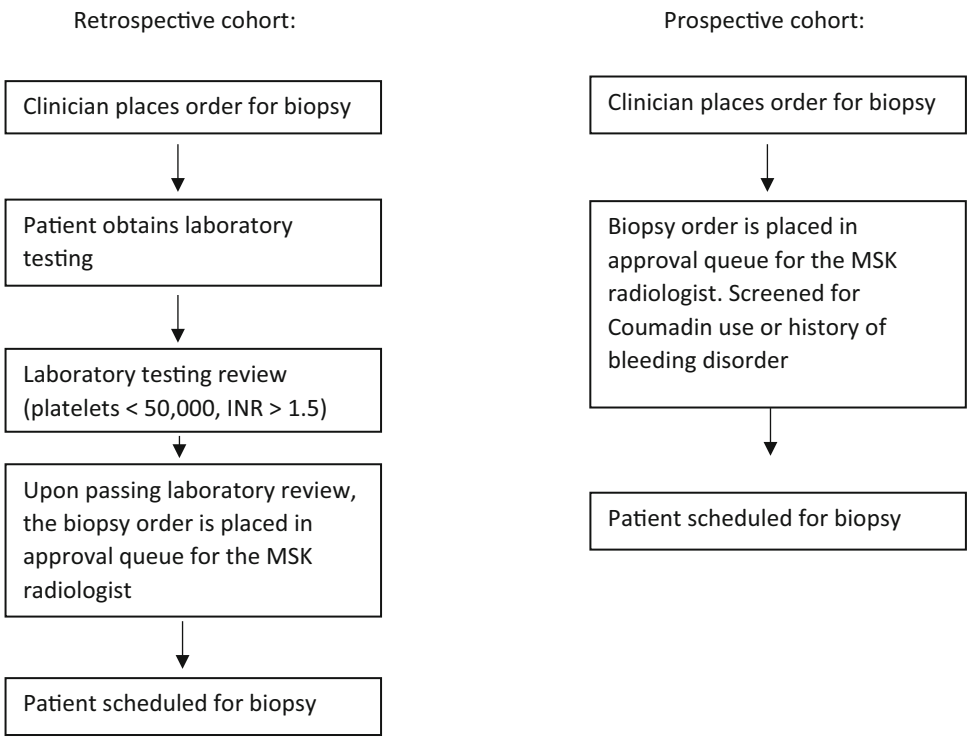

Fig. 1 Change in workflow process from when a biopsy is ordered to when a biopsy is performed

a retrospective comparison cohort. These patients were retrospectively identified using Nuance mPower Clinical Analytics (Nuance Communications, Inc., Burlington, Massachusetts). Between 7/1/2015 and 7/1/2017, all patients were required to undergo blood draws consisting of CBC and INR and all patients were required to stop NSAIDs and ASA for 5 days prior to procedure, per institutional protocol.

A priori, we considered a bleeding complication (CIRSE Grade 1) if there was bleeding after 15 min of manual compression of the biopsy site and/or if there was greater than 200 mL estimated blood loss. This was documented after each procedure.

Data collected included patient age, sex, location of biopsy, method of image guidance, cannula size, FNA and core needle biopsy gauge, number of passes of FNA and core needle biopsies, pathology results, and bleeding complication rate.

The bleeding complication rate was compared between patients in the prospective and retrospective cohorts for both bone biopsies and soft tissue biopsies. To assess whether the FNA and core needle gauge size affected the bleeding complication rate, the bleeding complication rate was compared by FNA and core needle gauge size for bone and soft tissue lesions separately for both cohorts.

Time to Biopsy

The number of days that elapsed from when a biopsy was ordered to when it was scheduled and the number of days from when the biopsy was scheduled to when it was performed were obtained for each patient in the prospective and retrospective cohorts. From these data, the number of days that elapsed from when a biopsy was ordered to when a biopsy was performed was calculated. The mean number of days in each category was also calculated and compared between the two cohorts. The mean (standard deviation) number of days elapsed from when the biopsy was ordered to when the biopsy was performed was calculated. The number of same day biopsies was compared between both prospective and retrospective cohorts.

Statistical Analysis

A sample size of 240 subjects (96 in the prospective cohort, and 144 in the retrospective comparison cohort) is required to have 80% power to detect a change in baseline complication rate of 1% to a hypothetical new complication rate of 10% assuming a Type I error rate of 0.05.

T-tests were used to compare quantitative demographic/clinical variables. The nonparametric Wilcoxon Rank-sum test was also used to compare the time from when biopsies were ordered to scheduled, and the time from when biopsies were ordered to performed in both cohorts given the skewness of the data. Fisher's exact test was used to compare the distribution of FNA and core needle gauge sizes between cohorts. Tests were two-sided and P values < 0.05 were considered statistically

significant. Statistics were performed using Rv 3.4 (https://www.r-project.org).

Results

Biopsies were performed using computed tomography guidance (CT) ($N = 435$; 218 in the prospective cohort, 217 in the retrospective cohort) or ultrasound guidance ($N = 220$; 114 in the prospective cohort, 106 in the retrospective cohort).

Bleeding Complication Rate

Prospective Cohort

In the prospective cohort, 110 out of 210 (52%) patients undergoing bone biopsy were male (Table 1). The mean age was 59.3 years (range 20–91 years). All 210 bone biopsies were guided by CT. Of the 122 patients undergoing soft tissue biopsy, 58 (48%) were male. The mean age of the prospective soft tissue biopsy cohort was 51.8 years (range 14–92 years) years. Out of the 122 soft tissue biopsies, 8 were guided by CT and 114 were guided by ultrasound. There was no bleeding complication in the prospective cohort (for soft tissue biopsies and for bone biopsies). There was no significant difference in bleeding complication between soft tissue biopsies guided by CT versus ultrasound [95% CI (0, 0), $P = 1.00$].

Table 1 Summary statistics for bone and soft tissue biopsies

Bone	Prospective ($N = 210$)	Retrospective ($N = 184$)	P
Mean age in years (SD)	59.3 (15.8)	58.1 (15.6)	0.231
Male sex (%)	110 (52.4%)	85 (46.2%)	0.227
Location (%)			0.005
Chest wall/sternum	12 (5.7%)	14 (7.6%)	
Rib	11 (5.2%)	13 (6.2%)	
Upper extremity	40 (19%)	42 (22.8%)	
Lower extremity	41 (19.5%)	41 (22.3%)	
Pelvis/hip	99 (47.1%)	66 (35.9%)	
Spine/intervertebral disk	1 (0.5%)	9 (4.9%)	
Paraspinal muscle	6 (2.9%)	0 (0%)	
CT-guided procedures (%)	210 (100.0%)	184 (100.0%)	1.00
Soft tissue	**Prospective ($N = 122$)**	**Retrospective ($N = 139$)**	**P**
Mean age in years (SD)	51.8 (16.7)	53.6 (18.4)	0.358
Male sex (%)	58 (47.5%)	57 (41.0%)	0.292
Location (%)			0.102
Abdominal Wall	1 (0.8%)	2 (1.4%)	
Chest wall/sternum	2 (1.6%)	11 (7.9%)	
Upper extremity	29 (23.8%)	25 (18%)	
Lower extremity	68 (55.7%)	81 (58.3%)	
Pelvis/hip	14 (11.5%)	18 (12.9%)	
Spine/intervertebral disk	0 (0%)	1 (0.7%)	
Paraspinal muscle	3 (2.5%)	1 (0.7%)	
Retroperitoneal lymph node	2 (1.6%)	0 (0%)	
CT-guided procedures (%)	8 (6.6%)	33 (23.7%)	< 0.001

SD standard deviation, *CT* computed tomography

Comparison Retrospective Cohort

In the retrospective cohort, 85 out of 184 patients (46%) were male (Table 1). The mean age of this cohort was 58.1 (range 13–85) years old. All 184 bone biopsies were performed with CT guidance. Core needle gauges were reported in all but 61 patients. Of the 139 patients undergoing soft tissue biopsy, 57 (41%) were male. The mean age of patients undergoing soft tissue biopsy was 53.6 (range 19–89) years. Approximately 24% (33/139) soft tissue biopsies were CT-guided and the other 76% (106/139) were ultrasound-guided. There was no bleeding complication in this cohort (for both bone and soft tissue biopsies). There was no significant difference in hemostasis between soft tissue biopsies guided by CT versus ultrasound [95% CI (0,0), $P = 1.00$].

There was no difference in bleeding complication rate between the prospective and retrospective cohorts [95% CI (0,0), $P = 1.00$]. There was no difference in the proportion of hypervascular metastasis with known propensity to bleed between the prospective and retrospective cohorts, for both bone and soft tissue biopsies (Table 2). There was no significant difference in FNA gauges used for bone and soft tissue biopsies between the cohorts (Table 3). There was a significant difference in core biopsy gauges used for bone and soft tissue biopsies, though this is in large part due to a lower gauge being used more frequently in the prospective cohort (Table 3). There was no significant difference in the number of FNA and core biopsy passes during bone biopsies between both cohorts (Table 4). There was a significant difference in number of FNA and core passes during soft tissue biopsies, though this is largely due to underreported/underperformed passes (Table 4). There was no significant difference in size of FNA and core biopsy gauges used and bleeding complication between the different gauges, both for bone and soft tissue biopsies between the cohorts [95% CI (0, 0), $P = 1.00$].

Table 2 Comparison of prospective and retrospective cohort bone and soft tissue biopsy pathology results

	Bone		*P*	Soft tissue		*P*
	Prospective (*N* = 210)	Retrospective (*N* = 184)		Prospective (*N* = 122)	Retrospective (*N* = 139)	
Hypervascular metastasis (%)	11 (5.2%)	11 (6.0%)	0.831	7 (5.7%)	4 (2.9%)	0.261
Non-hypervascular metastasis (%)	119 (56.7%)	98 (53.3%)	0.486	19 (15.6%)	23 (16.5%)	0.843
Primary bone or soft tissue sarcoma (%)	14 (6.7%)	6 (3.3%)	0.301	19 (15.6%)	39 (28.1%)	0.015
Nondiagnostic (%)	5 (2.4%)	4 (2.2%)	0.895	1 (0.8%)	2 (1.4%)	0.658
Other (%)	61 (29.0%)	65 (35.3%)	0.181	76 (62.3%)	71 (51.1%)	0.069

Hypervascular metastases include renal, thyroid, choriocarcinoma and melanoma

Other include lymphoma, infection or inflammatory conditions

Table 3 Comparison of prospective and retrospective cohort bone and soft tissue FNA and core needle gauges

Bone biopsy (FNA gauge)	Prospective phase (*N* = 210)	Retrospective phase (*N* = 184)	*P*
Not documented (%)	0 (0.0%)	5 (2.7%)	0.162
Not performed (%)	52 (24.8%)	60 (32.6%)	
20 (%)	12 (5.7%)	16 (8.7%)	
22 (%)	145 (69.0%)	107 (58.2%)	
25 (%)	0 (0.0%)	2 (1.1%)	
Soft tissue biopsy (FNA gauge)	(*N* = 122)	(*N* = 139)	*P*
Not documented (%)	2 (1.6%)	2 (1.4%)	0.566
Not performed (%)	9 (7.4%)	13 (9.4%)	
20 (%)	1 (0.8%)	4 (2.9%)	
22 (%)	105 (86.1%)	113 (61.4%)	
25 (%)	6 (4.9%)	7 (3.8%)	
Bone biopsy (core biopsy gauge)	Prospective phase (*N* = 210)	Retrospective phase (*N* = 184)	*P*
Not documented (%)	88 (41.9%)	61(33.2%)	< 0.001
13 (%)	102 (48.6%)	71(38.6%)	
15(%)	20 (9.5%)	52 (28.3%)	
Soft tissue biopsy (core biopsy gauge)	(*N* = 122)	(*N* = 139)	
Not documented (%)	2 (1.6%)	13 (9.4%)	< 0.001
14 (%)	93 (76.2%)	58 (41.7%)	
16 (%)	9 (7.4%)	11 (7.9%)	
18 (%)	17 (13.9%)	55 (39.6%)	
20 (%)	1 (0.8%)	2 (1.4%)	

P values calculated excluding patient where gauge sizes were unknown

Patients with elevated INR tests were rescheduled for biopsy in the retrospective study group. There was one patient (0.3%) who had elevated INR tests in the retrospective study group. Patients with low platelets were transfused with a 6-pack of platelets. There was 1 patient (0.3%) who had low platelets in the retrospective study group.

Time to Biopsy

Prospective cohort: The mean (standard deviation) of the number of days from when the bone biopsy was ordered to performed was 6.6 days (5.6). The mean (standard deviation) of the number of days from when the soft tissue biopsy was ordered to performed was 5.8 days (9.9). The

Table 4 Comparison of number of needle passes in the prospective and retrospective cohorts

Bone biopsy (FNA passes)	Prospective phase ($N = 210$)	Retrospective phase ($N = 184$)	Fisher's exact-test P
Not documented	53 (25.2%)	5 (2.7%)	0.443
Not performed	52 (24.8%)	56 (30.4%)	
1 (%)	15 (7.1%)	17 (9.2%)	
2 (%)	60 (28.6%)	61 (33.2%)	
3 (%)	19 (9.0%)	35 (19.0%)	
4 (%)	7 (3.3%)	7 (3.8%)	
5 (%)	2 (1.0%)	2 (1.1%)	
6 (%)	1 (0.5%)	0 (0%)	
8 (%)	1 (0.5%)	0 (0%)	
Soft tissue biopsy (FNA passes)	($N = 122$)	($N = 139$)	Fisher's exact-test P
Not documented	47 (38.5%)	3 (2.2%)	0.013
Not performed	9 (7.4%)	12 (8.6%)	
1 (%)	13 (10.7%)	11 (7.9%)	
2 (%)	41 (33.6%)	68 (48.9%)	
3 (%)	10 (8.2%)	37 (26.6%)	
4 (%)	1 (0.8%)	7 (5.0%)	
8 (%)	1 (0.8%)	0 (0%)	
Bone biopsy (core biopsy passes)	Prospective phase ($N = 210$)	Retrospective phase ($N = 184$)	Fisher's exact-test P
Not documented	88 (41.9%)	61 (33.2%)	0.635
1 (%)	2 (1.0%)	6 (3.3%)	
2 (%)	9 (4.3%)	15 (8.2%)	
3 (%)	25 (11.9%)	42 (22.8%)	
4 (%)	29 (13.8%)	32 (17.4%)	
5 (%)	27 (12.9%)	34 (18.5%)	
6 (%)	18 (5.7%)	22 (12.0%)	
7 (%)	5 (2.4%)	5 (2.7%)	
8 (%)	9 (4.3%)	7 (3.8%)	
9 (%)	6 (2.9%)	2 (1.1%)	
10 (%)	2 (1.0%)	5 (2.7%)	
11 (%)	1 (0.5%)	1 (0.5%)	
14 (%)	0 (0%)	1 (0.5%)	
Soft tissue biopsy (core biopsy passes)	($N = 122$)	($N = 139$)	Fisher's exact-test P
Not documented	51 (41.8%)	18 (12.9%)	0.420
1 (%)	0 (0%)	2 (1.4%)	
2 (%)	1 (0.8%)	3 (2.2%)	
3 (%)	13 (10.7%)	15 (10.8%)	
4 (%)	19 (15.6%)	29 (20.9%)	
5 (%)	18 (14.8%)	28 (20.1%)	
6 (%)	15 (12.3%)	29 (20.9%)	
7 (%)	4 (3.3%)	10 (7.2%)	
8 (%)	2 (1.6%)	15 (10.8%)	
9 (%)	0 (0%)	2 (1.4%)	
10 (%)	1 (0.8%)	1 (0.7%)	

number of same day biopsies was 38/332 (11.4%) (Table 5).

Retrospective cohort: The mean (standard deviation) of the number of days from when the bone biopsy was ordered to performed was 8.1 days (6.1). The mean (standard deviation) of the number of days from when the soft tissue biopsy was ordered to when the soft tissue biopsy was performed was 8.8 days (9.8). The number of same day biopsies was 11/323 (3.4%) (Table 5).

The overall time from ordering to performing a bone biopsy was significantly lower in the prospective group than the retrospective group [$P = 0.012$, 95% CI (0.34, 2.66 days), Wilcoxon P value = 0.004] (Table 5). The time from ordering to performing a soft tissue biopsy between the two cohorts was also statistically significant [$P = 0.015$, 95% CI (0.59, 5.41) days, Wilcoxon P value ≤ 0.001] (Table 5). The time from scheduling to performing both bone and soft tissue biopsies was significantly lower in the prospective group than the retrospective group [$P = 0.011$, 95% CI (0.26, 1.94) days, Wilcoxon P value = 0.002] and [$P < 0.001$, 95% CI (1.91, 4.29) days, Wilcoxon P value ≤ 0.001], respectively. The overall mean time savings for the patients in the prospective cohort was 3 days. There was a significant increase in percentage of same day biopsies in the prospective cohort [$P < 0.001$, 95% CI (4.05 to 12.15%)].

The estimated cost of a CBC and INR to the patient was obtained through our institution's financial department. The cost of a CBC is 27.55 Euros ($31.11 US Dollar, exchange rate 0.89), and the cost of an INR is 15.20 Euros ($17.17 USD), for a total of 42.75 Euros ($48.28 USD) per patient.

Discussion

The results of this prospective study suggest that image-guided biopsy of lesions in the extremities, non-intra-abdominal flank, or non-intrathoracic chest wall in most patients is a safe procedure that does not require preprocedural CBC and INR tests. There was no change in bleeding complication rate regardless of imaging modality used to guide the biopsy, the type of biopsy (bone versus soft tissue), gauge of the needle, number of FNA/core needle passes, or diagnosis. The data also suggested that there was no need to have patients stop taking NSAIDs/aspirin prior to biopsies. The ability for patients to continue taking aspirin is important especially for patients with increased stroke/cardiovascular risk using aspirin. Patients with acute or chronic pain syndromes would have less discomfort if they were able to continue taking NSAIDs prior to biopsies. These patients can continue to rely on NSAIDs to preserve daily function and obtain adequate

Table 5 Comparison between elapsed days between biopsy ordered to biopsy scheduled; and elapsed days between biopsy scheduled to biopsy performed

Bone biopsies	Prospective phase (N = 210)	Retrospective phase (N = 184)	P	Wilcoxon rank-sum P
Mean (SD) [median] elapsed days	1.9 (2.8)	2.3 (3.9)	0.249	0.187
Ordered to scheduled	[1]	[1]		
Mean (SD) [median] elapsed days	4.7 (4.3)	5.8 (4.2)	0.011	0.002
Scheduled to performed	[4]	[5]		
Mean (SD) [median] elapsed days	6.6 (5.6)	8.1 (6.1)	0.012	0.004
Ordered to performed	[6]	[7]		
Soft tissue biopsies	(N = 122)	(N = 139)	P	Wilcoxon rank-sum P
Mean (SD) [median] elapsed days	2.8 (8.8)	2.8 (7.0)	0.92	0.004
Ordered to scheduled	[1]	[1]		
Mean (SD) [median] elapsed days	3 (3.1)	6.1 (6.0)	< 0.001	< 0.001
Scheduled to performed	[2]	[5]		
Mean (SD) [median] elapsed days	5.8 (9.9)	8.8 (9.8)	0.015	< 0.001
Ordered to performed	[4]	[7]		
Number of same day biopsies (%)	38 (11.4%)	11 (3.4%)	< 0.001[a]	

[Median]

(Standard deviation)

[a]Fisher's exact test

rest. Eliminating the need to wait 5 days for the antiplatelet function of NSAIDs and aspirin also likely contributed to the decrease in wait time to biopsy.

Restricting preprocedural CBC and INR tests to select patients also reduced the time from when the biopsy was ordered to when the biopsy was performed, therefore decreasing the time to diagnosis for the patient. The time from when a clinician ordered a biopsy to when both bone or soft tissue biopsies were performed was significantly lower when preprocedural testing was restricted to only select patients. These findings may be attributed to decreased time required to either obtain laboratory testing orders or insurance approval, scheduling a laboratory visit, or verifying laboratory test results. A significant increase in rate of same day biopsies was also observed. This could be in large part related to the fact that patients were no longer required to have laboratory tests and could go immediately from the clinic office to the procedural suite.

The total cost to the patients in the retrospective comparison cohort was calculated by attributing a value of 42.75 Euros ($48.28 USD) to each patient that received preprocedural laboratory tests, for a total of 13,996.48 Euros (approximately $15,594.44 USD). The total cost savings to the patients in the prospective cohort were calculated by attributing a savings of $48.28 to each patient in the second cohort, for a total savings of 14.386.67 Euros (approximately $16.028.96 USD).

The Society of Interventional Radiology (SIR) has published consensus guidelines for preprocedural laboratory testing for all patients undergoing percutaneous image-guided interventions [14]. Bone and soft tissue biopsies are low risk/SIR category 1 (extremity) or moderate risk/SIR category 2 (spine/chest wall) procedures by SIR guidelines. The platelet count and hematocrit are "not routinely recommended" for patients in low and moderate risk categories per SIR guidelines. However, there are SIR treatment guidelines for patients with a low platelet count (less than 50,000/uL) and an elevated INR even in procedures in the low risk category (INR $>$ 2) [14], which implies that the platelet count and INR should be obtained to ascertain whether treatment for low platelet count or an elevated INR is necessary. The American Society of Anesthesiologists (ASA) also has consensus guidelines for preanesthesia laboratory testing [9]. The ASA task force guidelines are slightly different from the SIR guidelines and do not recommend testing of the hematocrit or coagulation tests (bleeding time, prothrombin time, partial prothrombin time, or platelet count) in asymptomatic or non-selected patients (extremes of age, anemia, bleeding disorders, and other hematologic disorders). The ASA performed a survey of 72 consultants and 234 ASA members about preprocedural laboratories. Only 3% of consultants and 1% of ASA members recommended routine coagulation studies for all patients [9]. Approximately 94% of consultants and 98% of ASA members agreed that

coagulation studies should be performed only in select patients [9]. The surveyed anesthesiologists' beliefs were in concordance with the results of this study.

Image-guided biopsy of lesions in the extremities, non-intra-abdominal flank, non-intrathoracic chest wall in most patients is a safe procedure that does not require preprocedural CBC and INR tests. There is insufficient data to extrapolate to spine biopsies, since only a single spine biopsy was done without preprocedural testing and without complication. The number of patients with either liver dysfunction, known bleeding disorder, or on anticoagulants that were required to obtain preprocedural CBC and INR in the prospective phase was very low (8/332, 2.4%). There was no bleeding complication in these patients. Von Willebrand disease is the most common bleeding diathesis and only has a prevalence of 1%, and does not have a sex bias [15, 16]. Therefore, the number of patients that have a bleeding disorder in the general population is expected to be very low.

Previous studies support our findings and have shown bleeding complication rates to be low in patients undergoing image-guided bone and soft tissue biopsies of the extremities and the spine [6, 17]. Shif et al. [18] reported a 1.1% complication rate in patients that did not have preprocedural laboratory tests and Liu et al. [19] reported a 1.6% complication rate. The procedural threshold complication rate, which includes bleeding, infection, and unintended organ injury, for non-lung percutaneous image-guided biopsies set by the SIR is 2% [20], which means these procedures should be safely able to be performed with a lower than 2% complication rate. These studies did not evaluate the decrease in time to biopsy and the increase in the percentage of same day biopsies that occurred using our revised criteria for preprocedural laboratory tests as demonstrated in this study.

The study has a few limitations. The results were from biopsies performed by fellowship-trained radiologists at a single tertiary academic institution and only included one biopsy of a vertebral body in the prospective cohort. Because the bleeding complication rate is, at a baseline, quite low, the power to identify small changes in the bleeding complication rate was limited. Also, bleeding complication was defined a priori; however, there is no consensus as to what defines a bleeding complication in the literature. It was unknown how many patients were on NSAIDs/aspirin in either group, though we assume that the percentage was likely similar in both cohorts. When examining the time to biopsy metrics, there are several factors that could affect the time to biopsy, such as patient preference for when to schedule the biopsy, interposed weekend days, and conflicts with other events in the patient's life. However, we anticipate that these same unmeasured variables were likely no different in the retrospective and prospective cohorts.

Conclusions

Image-guided biopsy of lesions in the extremities, non-intra-abdominal flank, or non-intrathoracic chest wall, in most patients is a safe procedure that does not require preprocedural CBC and INR tests. Patients can safely continue using aspirin and NSAIDs prior to these biopsies. Adopting these revised preprocedural laboratory criteria can result in decreased time from the biopsy being ordered to performed in the patient, so that a diagnosis can be achieved more rapidly. The revised preprocedural laboratory criteria can also result in an average cost savings of 42.75 Euros ($48.28 USD) at our institution.

Compliance with Ethical Standards

Conflict of interest Author S.T. reports royalties for Teleflex and Cook and is a consultant for Adrenas, MedComp, BD Bard, Lutonix, WL Gore, Cook, Teleflex.

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