The Oncologist, 2025, **30**, oyaf142
https://doi.org/10.1093/oncolo/oyaf142
Advance access publication 10 June 2025
Original Article

OXFORD

Ultrasound-guided core needle biopsy of nodular lesions of the spleen in hematology clinical practice

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Abstract

Background: Solid splenic lesions may be the expression of a lymphoproliferative disease spreading to the spleen or appear as the only manifestation of possible neoplastic diseases, mainly hematologic malignancies. Therefore, biopsy is of uttermost importance in clarifying their nature.

Patients and Methods: Forty-four patients with splenic nodular lesions suspected of hematologic disease underwent spleen contrast-enhanced ultrasonography and contextual biopsy using an 18-gauge needle. All procedures were performed on an outpatient basis. Patients with inconclusive findings or with a diagnosis of unaffected splenic tissue were followed up to discriminate between true and false-negative results.

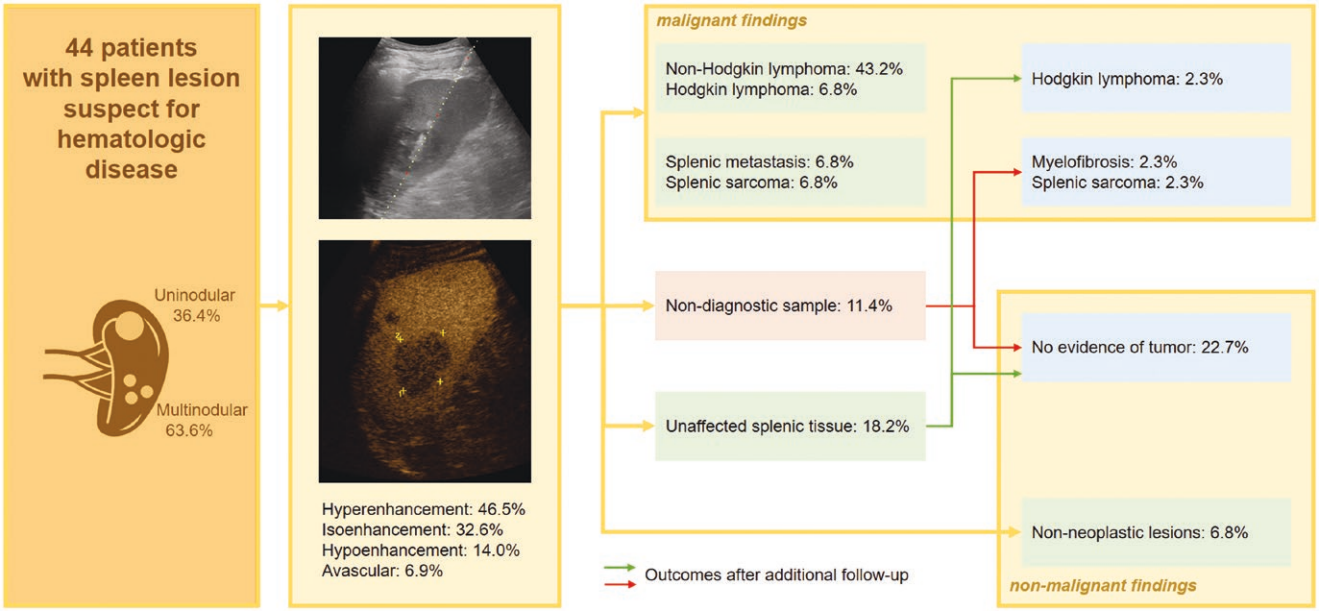
Results: All procedures ended up with sampling of splenic tissue without severe complications requiring hospitalization or supportive countermeasures. None was interrupted because of adverse event (AE)s. Out of 44 samples, a final diagnosis was accomplished in 39 cases, with a diagnostic yield of 88.6%. A diagnosis of lymphoma was made in 22 cases. Other diagnoses included: splenic metastases and splenic sarcoma (3 cases each), non-neoplastic lesions (3 cases), and unaffected splenic tissue (8 cases). Among the latter 8 patients, 1 received a diagnosis of Hodgkin lymphoma by marrow biopsy. All the other 7 patients never received a diagnosis of neoplasm and were true negative. Among the 5 patients with insufficient sampling, 3 were never diagnosed with a neoplasm during follow-up; 1 had myelofibrosis and 1 angiosarcoma. The sensitivity of the procedure was 96.6%; specificity was 100% and accuracy was 86.4%.

Conclusions: Ultrasound-guided core needle biopsy of splenic nodular lesions can be safely performed on an outpatient basis with no severe AEs.

Key words: contrast-enhanced ultrasound; lymphoma; nodular splenic lesion; spleen; ultrasound-guided spleen biopsy.

Received: 8 April 2025; Accepted: 11 May 2025.

Graphical Abstract



Implications for Practice

Contrast-enhanced ultrasound-guided core needle biopsy of the spleen is a powerful tool to be applied in daily hematology clinical practice when isolated nodular lesions of the spleen suspicious for lymphoproliferative or neoplastic localizations are encountered. It allows a timely and accurate diagnosis with a safe, radiation-sparing, and minimally invasive method that obviates diagnostic splenectomy.

Introduction

Nodular splenic lesions are incidentally found in otherwise healthy patients during routine imaging,[1] and only in a minority of cases they are accompanied by symptoms, such as vague abdominal or left hypochondriac discomfort. Solitary or multiple solid nodules may be the expression of benign or malignant processes involving the spleen, the latter being a heterogenous group that encompasses dendritic/reticulum cell sarcomas, epithelial metastases of neoplasms originating outside of the spleen and hematologic malignancies.[2,3] Among lymphomas and lymphoproliferative disorders, focal splenic lesions are in general rather common, despite any detectable organ enlargement, although most frequently presenting synchronously with other manifestations of the underlying disease, such as superficial or abdominal lymphadenopathies or peripheral blood alterations, mainly lymphocytosis. Single or multiple solid nodules of the spleen, however, may be the unique manifestation of a neoplastic process involving the spleen, albeit much more rarely, and may be encountered in hematological everyday clinical practice.[4]

If on the one hand splenectomy has represented the gold standard for histopathological diagnosis, at least if a suspicion of malignant localization to the spleen was very likely, on the other imaging-guided core needle biopsy of the spleen represents an ideal strategy to obtain an adequate amount of tissue from the lesion thus avoiding splenectomy. This allows the preservation of the immunologic function of this organ, should the patient require any subsequent chemotherapy or immunotherapy approach. Moreover, it becomes strictly necessary if a precise and accurate diagnosis is required.[5] Contrast-enhanced ultrasonography (US) improves the detection and characterization of focal splenic lesions and thus appears useful in finding a possible target for biopsy.[6]

The purpose of this paper is to describe our single-center experience with contrast-enhanced US-guided core needle biopsy of nodular lesions of the spleen encountered during everyday clinical practice at a third-level hematology institution, with a particular focus on the diagnostic accuracy of the procedure and its feasibility in an outpatient setting, while highlighting its safety implications.

Methods

Study overall conduct

All consecutive cases of splenic nodular lesions suspected of hematologic disease spreading to the spleen and requiring histological characterization were addressed to splenic contrast-enhanced US and contextual core needle biopsy. Adult patients with both a de novo onset of nodular splenic lesions and with a history of hematologic disease—with a suspicion of disease progression or relapse—were considered eligible for the contrast-enhanced US-guided procedure. Patients were excluded if splenic lesions occurred concomitantly with another affected site that could be more easily biopsied, as in the case of superficial and palpable lymph nodes, or if a reliable diagnosis was thought to be obtained by bone marrow trephine biopsy only. Patients were also excluded if a core needle biopsy was considered risky or contraindicated due to active bleeding, hemorrhagic diathesis, or anatomical impediments.

In case of inconclusive findings (ie, if the sample was inadequate to perform a histopathological diagnosis) or if the pathology report concluded for unaffected splenic tissue,

patients were closely followed up by a hematologist to check for any symptom or any further sign of hematologic disease, in order to discriminate between true and false-negative results. Repeated biopsy could be indicated to rule out or confirm a diagnosis of hematologic neoplasm.

The main objective of the study was to evaluate the reliability of the procedure in establishing a diagnosis of hematologic neoplasm involving the spleen, which was measured by sensitivity, specificity, positive and negative predictive values, and diagnostic accuracy. Safety was also a major objective. Demographics and patients' characteristics were summarized by descriptive statistics. Diagnostic accuracy was calculated as the ratio between the sum of true positive and true negative cases and the total number of enrolled patients. Safety was established by documenting any adverse event (AE) that occurred during the maneuver, which was encoded according to the National Cancer Institute Common Terminology Criteria for AE, version 4.3.

Demographics and patients' characteristics were summarized by descriptive statistics. Comparison between groups was performed—for categorical variables—using the contingency table analysis with the chi-squared or Fisher's exact test, as appropriate, whereas continuous data were analyzed using a Student's *t*-test, after checking whether data are normally distributed (based on the Shapiro–Wilk statistic), or a Wilcoxon rank-sum test otherwise. All tests were two-sided and a *P*-value of <.05 was considered statistically significant. Statistical analyses were performed with Stata 17 (StataCorp LP, TX).

The study had official approval by our Ethical Committee (approval id 1043/2021/Oss/AOUBo) and it was conducted in accordance with the Declaration of Helsinki. Written informed consent was always preliminarily obtained.

Practical considerations

Biopsies have been performed in real-time US after choosing the most appropriate path according to their disposition within the splenic parenchyma.

Platelet counts higher than $50 \times 10^3/\mu L$, an adequate coagulation asset including an International Normalized Ratio lower than 1.5, withdrawal from antiplatelet drugs, and anticoagulant agents were all prerequisites to reduce the bleeding risk correlated to the biopsy. At least 4 days of withdrawal from antiplatelet drugs, at least 12 hours since the last administration of low-molecular-weight heparin, at least 1 day after the last dose of any activated factor X inhibitor and normalization of International Normalized Ratio in patients receiving warfarin were required. Twelve hours of fasting was prescribed before the procedure. Intravenous low-dose tranexamic acid (500 mg, 1 vial) was administered as bolus before starting in patients who were clinically judged at higher risk of bleeding complications, provided they had neither any previous or recent history or cardiovascular disease nor they were on anticoagulants or antiplatelet agents (due to the anti-fibrinolytic mechanism of tranexamic acid).

A LOGIQ E10 ultrasound machine was used, equipped with a C1-6-D probe and an L2-9-D probe. The C1-6-D probe operates at a frequency range of 1-6 MHz, allowing for deeper penetration, while the L2-9-D probe provides higher spatial resolution. A needle guide adapter compatible with the probe, featuring a 4-angle approach for improved anatomical access, was used. This system enables precise needle placement according to real-time ultrasound guidance displayed on the screen. To increase the precision of the histological sample, avoid necrotic tissue, and identify the most suitable site for biopsy, contrast-enhanced US with contrast media (SonoVue, Bracco©) was performed.

The biopsy path was meticulously planned to determine the most suitable route, choosing between an anterior, lateral, or posterior abdominal approach while carefully avoiding the pleura, intestines, and major vessels. Lesions that were not clearly identifiable or safely accessible by ultrasound guidance were excluded from biopsy, in accordance with standard clinical practice. The skin was sterilized, and only local anesthesia was administered (lidocaine hydrochloride 2% solution). A modified Menghini 18-gauge needle was used, and 1 or 2 needle passes were performed depending on the required sample size. The patient was positioned in a left lateral decubitus position (lying on the left side) to facilitate compression using an abdominal compression belt, similar to the technique employed in renal biopsy procedures.

Procedures were performed in all cases on an outpatient basis. Upon completion, all patients were prescribed post-biopsy monitoring in bed for 2 hours, to monitor for any complications. US examination was repeated only in case of an outbreak of pain to check for any post-procedural complications, especially bleeding.

Results

Patients characteristics

Forty-four patients underwent a contrast-enhanced US-guided core needle biopsy of the spleen on an outpatient basis at a median age of 57.5 years (range: 19-82) between July 2013 and October 2023. Twenty-four were males and 20 females, displaying a single nodular lesion of the spleen in 16 cases (36.4%) or a multinodular splenic involvement in 28 cases (63.6%). Eleven patients had a previous history of hematologic disease and in 5 cases the procedure was done in patients with known active neoplastic disease.

Upon preliminary US evaluation, 27 patients displayed splenomegaly (61.4%), mild in 11 cases, moderate in 9 and severe in 7. Spleen measures were unavailable in 6 patients. Mild splenomegaly was defined as a bipolar diameter between 12 and 14 cm, with a cross-sectional area of 45 to 60 cm^2; moderate splenomegaly was 14 to 16 cm in diameter with an area of 60 to 90 cm^2; severe splenomegaly was characterized by a diameter longer than 16 cm and an area higher than 90 cm^2. At B-mode, splenic lesions were hypoechoic in 36 cases (81.8%), isoechoic and hyperechoic in 3 cases each (6.8%), and never anechoic. In 2 cases (4.6%), the lesion was hypoechoic with a hyperechoic border. Contrast-enhanced US was performed in all but one case, with hyperenhancement in 20 cases (46.5%), isoenhancement in 14 (32.6%), hypoenhancement in 6 (14.0%) and avascular behavior in 3 cases (6.9%). Washout was documented in 35 cases (81.4%; Figure 1). The mean length of the maximum diameter of the target lesion was 40 mm (range: 9-150). Lesions under 20 mm were in general more superficial and in favorable and safe locations for puncture.

Histology results and correlations with US parameters

All the procedures ended up with a sampling of splenic tissue and repetition was never necessary. Out of 44 samples, a final

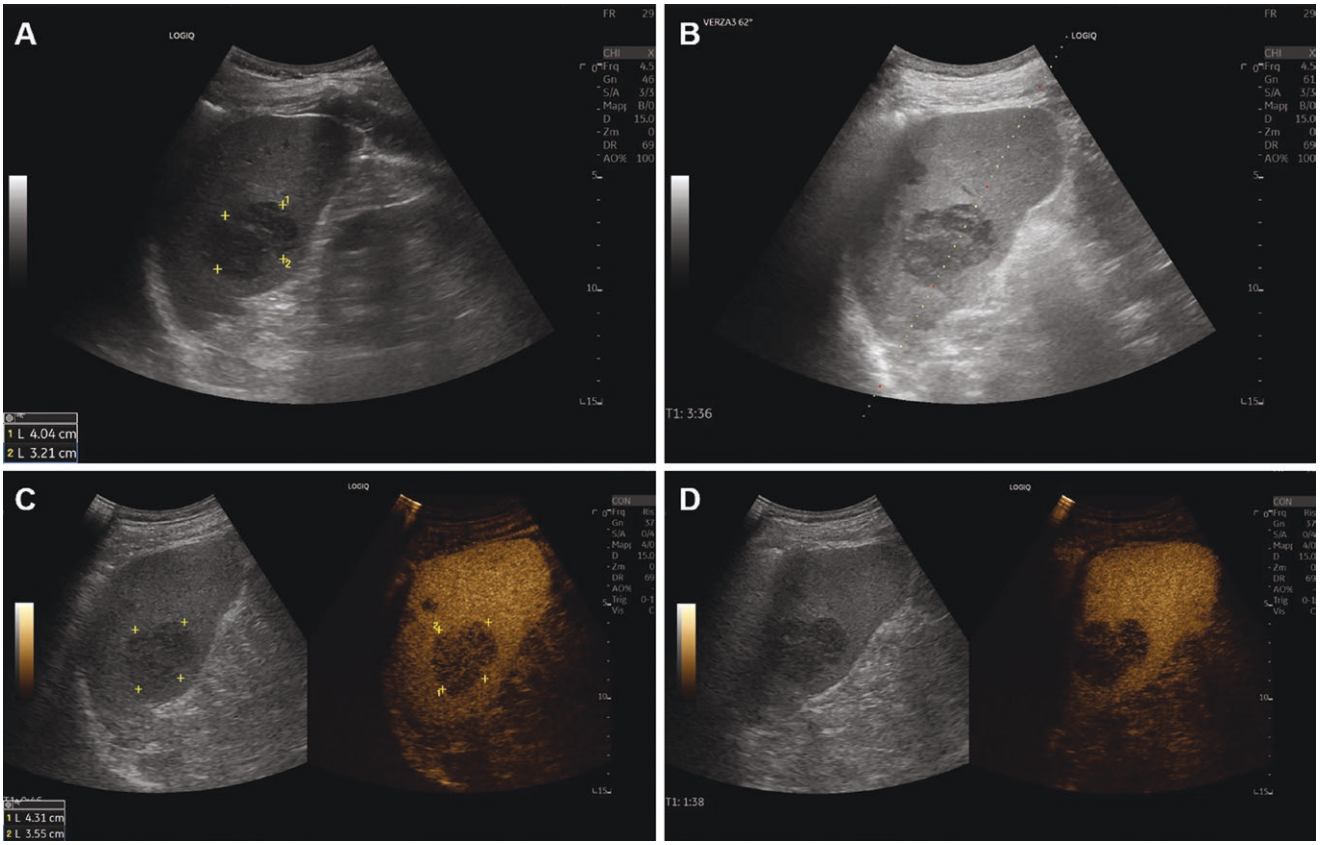


Figure 1. Hypoechoic splenic lesion at B-mode (panel A) with highlighted biopsy path (panel B). Contrast-enhanced US behavior (arterial phase) at administration (panel C) and washout after 1:38 minutes (panel D).

diagnosis was accomplished in 39 cases, which turned into a diagnostic yield of 88.6%. The diameter of the target lesion did not turn out to be detrimental to the success of the procedure. The amount of tissue taken was adequate to perform fluorescence in situ hybridization when it was considered necessary by the pathologist to establish the diagnosis. A diagnosis of lymphoma was formulated in 22 cases: non-Hodgkin lymphoma in 19 cases and Hodgkin lymphoma in 3 cases. More precisely, the great majority of patients had a final diagnosis of diffuse large B-cell lymphoma (DLBCL). Table 1 includes the detailed breakdown of histological diagnoses other than DLBCL within non-Hodgkin lymphoma patients. Diagnoses other than lymphoma included: splenic metastasis of carcinoma in 3 cases, splenic sarcoma in 3 cases, and non-neoplastic lesions in 3 cases, including one case of pseudo-inflammatory tumor (PT). In 8 cases, the final diagnosis was unaffected splenic tissue: this condition mostly occurred if the selected target was a lesion smaller than the mean diameter of 40 mm.

Among the 11 patients with a history of hematologic disease, the final diagnosis was non-Hodgkin lymphoma in 3 cases (27.3%), Hodgkin lymphoma in one case (9.1%), splenic metastases in 2 cases (18.2%), normal splenic tissue in 3 cases (27.3%) and PT in one case (9.1%). In one case we obtained insufficient material for diagnosis (9.1%). Among the 5 patients with active neoplastic disease, 2 had splenic localization of non-Hodgkin lymphoma (with histologic features of aggressive transformation), one showed a splenic metastasis of carcinoma and in one case we got normal splenic tissue. In the remaining case, the specimen was inadequate.

In the 22 patients with a final diagnosis of lymphoma, spleen involvement was uninodular in 7 cases and multinodular in 15. All patients displayed hypoechoic lesions at B-mode, with contrast isoenhancement in 50.0% of the cases, hyperenhancement in 36.4%, and hypoenhancement in 9.1%; in one case, the lesion remained avascular (4.5%). Contrast washout was observed in 86.4% of the cases. Most patients had no or mild splenomegaly (54.5%), while it was severe in only 18.2% of the cases.

Lesion echogenicity was indeed more heterogeneous in patients with a non-lymphomatous diagnosis, although hypoechoic findings remained prevalent (63.6%), together with isoechoic and hyperechoic lesions in 13.6% of the cases each. Interestingly, hyperenhancement at contrast-enhanced US was found in 54.5% of the cases and isoenhancement in 13.6%, in an opposite fashion to patients with lymphoma.

No differences were observed regarding age at biopsy and gender between patients with a final diagnosis of lymphoma and those without lymphoma (58.5 vs 56.0 years, $P = .5859$ and 11 males vs 13 males, $P = .7626$, respectively).

Fluorodeoxyglucose (FDG) positron emission tomography (PET) scan was widely performed, both as an aid to better characterize splenic lesions and for staging purposes in case of neoplastic findings. Overall, 75.0% of the patients were also evaluated by PET and all lesions but one turned out to be FDG avid. Table 2 compares the clinical and US characteristics of patients according to their final diagnosis. Noteworthy, the distribution of lesion echogenicity at B-mode and contrast behavior in terms of enhancement of the target lesion differed significantly between patients with a final diagnosis of lymphoma versus no-lymphoma ($P = .035$ and 0.047,

Table 1. Histological results and outcomes of negative cases at follow-up. (*) Percentages calculated out of all 44 cases.

Biopsy outcomes (*N* = 44)	Cases	Follow-up of negative cases
Non-Hodgkin lymphoma (*)	19 (43.2%)	—
Diffuse large B-cell lymphoma	14 (31.8%)	
B-cell lymphoma, unspecified	3 (6.8%)	
Anaplastic large cell lymphoma	1 (2.3%)	
Small lymphocytic lymphoma	1 (2.3%)	
Hodgkin lymphoma	3 (6.8%)	—
Solid tumor metastasis	3 (6.8%)	—
Renal carcinoma	1 (2.3%)	
Hepatocellular carcinoma	1 (2.3%)	
Cancer of unknown primary	1 (2.3%)	
Splenic sarcoma	3 (6.8%)	—
Non-neoplastic lesions	3 (6.8%)	—
Normal splenic tissue	8 (18.2%)	Hodgkin lymphoma: 1 (2.3%)
		No evidence of tumor: 7 (15.9%)
Non diagnostic sample	5 (11.4%)	Myelofibrosis: 1 (2.3%)
		Angiosarcoma:1 (2.3%)
		No evidence of tumor: 3 (6.8%)

Table 2. Clinical and echotomographic characteristics of patients with a confirmed histological diagnosis of lymphoma (22 patients) compared to those of patients with a non-lymphomatous diagnosis (22 patients).

Characteristics		Lymphoma (*N* = 22)	No lymphoma (*N* = 22)	*P*
Mean maximum diameter of the target lesion (40 mm in all pts.)		45 mm	34 mm	.0881
Splenomegaly	None	22.70%	27.20%	.0523
	Mild (Ø 12,14 cm, area 45,60 cm^2)	31.80%	18.20%	
	Moderate (Ø 14,16 cm, area 60,90 cm^2)	18.20%	22.70%	
	Severe (Ø > 16 cm, area > 90 cm^2)	18.20%	13.60%	
	Unavailable data	9.10%	18.20%	
Lesion echogenicity (at B-mode)	Hypoechoic	100%	63.60%	.035
	Isoechoic	0	13.60%	
	Hyperechoic	0	13.60%	
	Anechoic	0	0	
	Other	0	9.10%	
Contrast behavior	Isoenhancement	50.00%	13.60%	.047
	Hyperenhancement	36.40%	54.50%	
	Hypoenhancement	9.10%	18.20%	
	No enhancement (avascular)	4.50%	9.10%	
	Not performed	0	4.50%	
Washout		86.40%	72.70%	.0519
Concurrent PET-FDG				
Availability		72.7% (16/22 pts.)	77.2% (17/22 pts.)	.7277
FDG-positive rate		100% (16/16 pts.)	94.1% (16/17 pts.)	.3245

respectively). Washout was slightly more frequently observed in patients with lymphoma than in those bearing non-lymphomatous nodules, although the difference remained statistically insignificant. Conversely, maximum spleen diameter, mean maximum diameter of the target lesion, and FDG-PET positive rates were not significantly different between patients affected by lymphomatous and non-lymphomatous lesions.

Reliability of the procedure

Among the 8 patients whose final histopathological diagnosis was unaffected splenic tissue, one received a diagnosis of Hodgkin lymphoma by marrow biopsy (this represented the only false-negative case). All the other 7 patients never received a diagnosis of a neoplasm as they did not show any symptoms or clinical signs suspicious of hematologic

or neoplastic disease during subsequent follow-up. For this reason, they were considered true negative cases. Among the 5 patients in which the sample was inadequate for a final diagnosis, 3 were never diagnosed with any neoplasm during follow-up, while 1 had myelofibrosis (upon bone marrow biopsy) and 1 had splenic angiosarcoma (Table 1).

The main findings of the study are reported in Table 3: given a positive predictive value for the diagnosis of neoplastic involvement of the spleen in the case of single or multiple nodular lesions of 100% and a negative predictive value of 90.9%, the diagnostic accuracy reaches 86.4%, with a sensitivity of 96.6% and a specificity of 100%.

Safety

None of the procedures was interrupted because of an AE. Patients complained of pain in 2 cases (4.5%), although this symptom was just transient and resolved completely in the immediate post-maneuver monitoring. Intravenous paracetamol was administered in 3 cases (6.8%). No bleeding events were documented and none of the patients needed overnight hospitalization for unresolved AE, more intensive or prolonged monitoring, or medication requirements. Of note, tranexamic acid was administered in 18 cases (40.9% of the patients) as a prophylaxis against bleeding as previously outlined.

Discussion

Indications to spleen biopsy are represented by any isolated solid focal lesion in case of active or suspected lymphoma or extra-splenic neoplasm in general, as well as in immunocompromised patients and in case of fever of unknown origin along with splenic morphologic abnormalities, to rule in or out any possible localization of neoplastic disease.[5] Patients encountered in the everyday hematology practice may therefore qualify for a splenic core needle biopsy as soon as a histologically confirmed diagnosis is required.

Given the conspicuous vascular component of this organ, hemorrhagic risk has always been perceived as a major concern and has hampered the prompt application of this procedure. It has been demonstrated that this is an indeed safe approach, provided the patient is adequately prepared and any major risk factor for bleeding (eg, high systolic blood pressure, low platelet counts, and anticoagulation drugs) is minimized,[7] regardless of the caliber of the needle used (18-gauge vs thinner or larger ones). Intuitively, the larger the caliber of the needle, the better the diagnostic yield but the higher the rate of major complications, including bleeding, as shown in literature.[8-17] Recently, Kavandi and colleagues, in a cohort of 239 patients undergoing splenic biopsy under computed tomography or US guidance, showed a rate of hemorrhagic complications around 8%, with nearly 2% requiring treatment. Most hemorrhagic complications occurred during the biopsy itself or within the first 3 hours, while just a few were detected later. Interestingly, patients with leukemia and lymphoma were among the less likely to bleed after a biopsy compared to patients undergoing a biopsy under other conditions, including benign diseases.[18]

The absence of hemorrhagic AE in our experience confirms that the procedure is highly safe and affordable on an outpatient basis: the preoperative evaluation of any potential bleeding risk, together with the thorough planning of the biopsy path are both relevant aspects for its safety. Prophylactic administration of tranexamic acid in patients judged at higher risk of bleeding complications, as shown in our case series, could also help in reduce the bleeding rate. Although its positive impact on surgical bleeding has been demonstrated, as it reduces the probability of receiving blood transfusion by at least a third,[19] no data are available at present in the splenic biopsy setting, and somewhat controversial results have been reported on transrectal prostate and percutaneous kidney biopsies,[20,21] as well as on isolated blunt injuries of the liver and the spleen.[22]

The procedure is at the same time highly reliable with the use of an 18-gauge needle, as it reaches a sensitivity of 96.6%, an accuracy of 86.4% in the diagnosis of any neoplastic disease and a diagnostic yield as high as 88.6%, which all compare favorably with already reported data.[13-15] This turns into splenic preservation, most of all in the absence of splenomegaly-related symptoms and in patients who are likely to require anti-neoplastic treatments soon after diagnosis, thus taking advantage of the intact immunologic function of this organ.

US parameters, namely lesion echogenicity, contrast behavior, and washout, are helpful in corroborating the suspect of malignancy before performing the biopsy. In a wide study with 139 patients with focal splenic incidentalomas, excluding purely cystic anechoic lesions, a multiparametric US study was able to reveal different malignancy rates depending on the B-mode US and contrast-enhanced US patterns.[23] More specifically, malignancy rates of 16.2% and 6.3% were documented among patients who displayed a hypoechoic + iso-hypoenhancement contrast-enhanced US pattern and hyperechoic + iso-hypoenhancement contrast-enhanced US pattern, respectively, whereas all the other combinations were never correlated with a final diagnosis of malignancy. This work supports the hypothesis that all patients with a hypoechoic or hyperechoic lesion with arterial iso-hypo-enhancement should be addressed through further imaging, very close follow-up, and eventually splenic sampling.[23] In our case series, all patients were judged eligible for biopsy due to an a priori multiparametric combined US and contrast-enhanced US evaluation (integrated with anamnestic information and PET scan, when available) that posed them a high risk of splenic malignancy. Interestingly, once the final diagnosis was made, we found that all patients

Table 3. Reliability measures of the procedure. (*) It refers to the diagnosis of any splenic neoplastic disease. (**) It refers to the reliability of the procedure in formulating any kind of diagnosis.

Outcome	*N* (%)
True positive for neoplasm	28 (63.6%)
True negative for neoplasm	10 (22.7%)
False negative for neoplasm	1 (2.3%)
False positive for neoplasm	0
Insufficient sample	5 (11.3%)
Total	44 (100%)
Endpoint	**%**
Sensitivity (*)	96.6
Specificity (*)	100
Positive predictive value (*)	100
Negative predictive value (*)	90.9
Diagnostic accuracy (*)	86.4
Diagnostic yield (**)	88.6

with lymphoma had a hypoechoic pattern compared to somewhat more variable appearances at the B-mode of all the other non-lymphomatous lesions. Conversely, contrast-enhanced US patterns were spread between both iso-hypoenhancement, in 59.1% of the cases, and hyperenhancement, in 36.4%, as far as lymphoma patients are concerned versus 31.8% and 54.5%, respectively, in non-lymphoma patients. If we apply the aforementioned classification in our cohort, among the 14 patients with hypoechoic and hyperenhancement contrast-enhanced US pattern we found a rate of malignancy of 64.3% (8 lymphomas + 1 splenic metastasis), that rises to 73.7% (13 lymphomas + 1 splenic sarcoma) when a hypoechoic + iso-hypoenhancement pattern is considered. In our opinion, all patients with a B-mode hypoechoic lesion of the spleen, regardless of any peculiar contrast-enhanced US behavior, should be considered for further imaging and splenic sampling, even more, if they display contrast washout and if their clinical history could be highly suggestive of malignancy.

The strength of this study is represented by the fact that the same US technique—performed preferentially by the same team of operators—has been applied to all patients, differently by most published papers in which image guidance is based on either US or computed tomography: this is obviously in favor of a more homogeneous approach to the patient. Moreover, we have for the first time described the possible role of intravenous tranexamic acid as a pre-emptive approach to bleeding complications following splenic puncture in selected high-risk patients, although this study was not specifically designed to test this hypothesis.

On the other hand, a drawback is represented by the lack of a second histological confirmation in case of an initially negative biopsy (ie, normal splenic tissue and inconclusive samples), at least in most of the cases. The absence of neoplasm was established by clinical follow-up in 10 out of 13 negative cases, as patients have neither developed signs or symptoms of active splenic disease nor splenic lesions have shown a tendency to increase or worsen over time. Only 3 patients received a second sampling (2 received a bone marrow biopsy and 1 underwent surgical splenectomy, but never repeated the spleen needle biopsy), which was considered necessary to establish a precise diagnosis given the persistence of a high suspicion of a neoplastic disease. We ended up with a diagnosis of hematologic disease in 2 cases (namely, a stage IV Hodgkin disease and myelofibrosis, respectively), while in the third case, a post-splenectomy diagnosis of splenic angiosarcoma was made. Another possible limitation, due to the monocentric nature of this study, is that we cannot have direct confirmation of our results outside our hospital, thus lacking information on their reproducibility.

Conclusion

In conclusion, contrast-enhanced US-guided core needle biopsy of splenic lesions is a powerful tool to be applied in daily hematology clinical practice when isolated nodular lesions of the spleen suspicious for lymphoproliferative or neoplastic localizations are encountered. This allows a timely diagnosis with a safe, radiation-sparing, and minimally invasive method that obviates diagnostic splenectomy. A cautious preoperative evaluation of the patient is of uttermost importance for a successful procedure, as well as post-procedural monitoring for any outbreaking complications.

Author Contributions

Alessandro Broccoli: conceptualization, data curation, formal analysis, writing (original draft preparation), writing (review & editing). Sofia Maria Bakken: data curation, investigation, resources, writing (original draft preparation), writing (review & editing). Lisa Argnani: data curation, formal analysis, writing (original draft preparation), writing (review & editing). Camilla Mazzoni, Davide Di Benedetto, Marta Machado, Livia Masi, Nicola Venturoli, Daniela Agostinelli, Beatrice Casadei, Gabriele Gugliotta, Cinzia Pellegrini, Vittorio Stefoni: data curation, investigation, resources, writing (review & editing). Carla Serra: conceptualization, data curation, investigation, supervision, resources, writing (original draft preparation), writing (review & editing). Pier Luigi Zinzani: conceptualization, supervision, writing (original draft preparation), writing (review & editing).

Funding

None.

Conflict of Interest

Authors declare they have no conflict of interest pertaining to this work to disclose.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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