

RESEARCH ARTICLE

Impact of focused cardiac ultrasound in vascular surgery patients: A prospective observational study

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Abstract

Purpose: We aimed to evaluate the diagnostic and logistical consequences of routine preoperative focused cardiac ultrasound (FOCUS) in patients scheduled for elective vascular surgery.

Methods: In a prospective, observational study, FOCUS was performed in all patients seen in the vascular surgery outpatient clinic from January 14 to May 1, 2019, unless a full echocardiography had been conducted in the preceding 12 months or the patient was already referred to an echocardiography by the vascular surgeons. FOCUS followed a stringent protocol and referrals for a full echocardiography followed predefined criteria.

Results: Preoperative FOCUS was performed in 55 (60%) patients. Of these, 12 patients (22%) revealed cardiac pathology and were referred to a full echocardiography. Coronary angiography was subsequently performed in one of these patients but was without a further consequence. All patients underwent surgery.

Conclusion: FOCUS disclosed cardiac pathology in the outpatient clinic but with little clinical consequence. This study does not support routine FOCUS as a part of the preoperative patient cardiovascular assessment before vascular surgery. However, larger studies are warranted to further evaluate the relevance of preoperative FOCUS in a larger sample size.

KEYWORDS

myocardial injury, preoperative focused cardiac ultrasound, preoperative planning, vascular surgery

1 | INTRODUCTION

Perioperative myocardial infarction, heart failure, and arrhythmia are associated with increased length of stay and mortality in noncardiac surgery.^{1,2} This association is especially pronounced in vascular surgery where myocardial injury is highly prevalent, asymptomatic, and without electrocardiogram changes but, despite this, an independent risk factor for cardiovascular complications and death.^{2,3} Hence, intraoperative factors, including circulatory instability resulting in blood flow reduction

and hypotension, are likely key causative components for patient outcomes. Avoidance of circulatory instability with patient-tailored anesthesia is contingent on detailed knowledge of the patients' preoperative cardiovascular status. However, cardiovascular performance and the resulting physical potential may be difficult to assess in vascular surgery patients due to exercise incapacities.³⁻⁵

Preoperative focused cardiac ultrasound (FOCUS) has been proposed to bridge this gap in knowledge by elucidating unknown structural cardiac disease and reduced biventricular function.⁶ This allows

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TABLE 1 Protocol for focused cardiac ultrasound

Apical four-chamber view	Parasternal long-axis view	Categorical criteria and definition of normality
Left ventricular EF by eye-balling (%)	Left ventricular EF by eye-balling (%)	Normal ($52\% \leq EF \leq 72\%$) Mildly impaired ($41\% \leq EF \leq 51\%$) Moderately impaired ($40\% \leq EF \leq 30\%$) Severely impaired ($EF < 30\%$)
-	Left ventricular end-diastolic diameter (mm)	Normal (male ≤ 58 mm; female ≤ 52 mm)
-	Left ventricular posterior wall thickness (mm)	Normal (< 13 mm)
-	Interventricular septum thickness (mm)	Normal (< 13 mm)
Right ventricular end-diastolic diameter (mm) ^a	-	Normal (≤ 41 mm)
TAPSE (mm)	-	Normal (≥ 17 mm)
Aortic valve	Aortic valve	Normal ^b Aortic valve stenosis ^c Aortic valve insufficiency ^d Combination of aortic valve stenosis and insufficiency
Mitral valve	Mitral valve	Normal ^b Mitral valve stenosis ^c Mitral valve insufficiency ^d Combination of mitral valve stenosis and insufficiency
Pericardial effusion	Pericardial effusion	No Yes (> 5 mm)
Obvious pathology present, but not described above	Obvious pathology present, but not described above	No Yes (description)

Abbreviations: EF, ejection fraction, TAPSE, tricuspid annular plane systolic excursion.

^aAt the tricuspid annular plane level.

^bSufficient opening and co-adaption of leaflets seen.

^cLeaflets calcified and restricted in movement.

^dInsufficient co-adaption seen OR insufficiency seen with two-dimensional Doppler.

the anesthesiologist to optimize the patients' hemodynamic status prior to surgery and subsequently provides individualized anesthesia during surgery.⁴ The application of preoperative FOCUS has been shown to alter patient treatment in acute abdominal and orthopedic surgery.^{6,7} The prevalence of unknown, concomitant cardiac disease is expected to be high in vascular surgery patients. Further, positive FOCUS findings merit an additional diagnostic workup, which may influence and interrupt patient flow from the outpatient clinic to the time of surgery. The primary objective of this study was to quantify FOCUS findings in patients scheduled for elective vascular surgery, and the secondary objective was to describe the downstream diagnostic and logistical consequences of positive FOCUS findings.

2 | MATERIALS AND METHODS

This was a prospective, observational, single-center, quality control study, which evaluated the downstream effects of institutionally initiated, basic screening for structural cardiac disease during a limited time period. In Denmark, institutionally approved quality control studies are exempt from ethical approval, and anonymous data can be published without a written consent from the patients. Patients scheduled for elective vascular surgery in general- or neuro-axial anesthesia in a predefined period

from January 14 to April 30, 2019, were eligible for inclusion. FOCUS was performed in all patients seen in the vascular surgery outpatient clinic unless a full echocardiography had been conducted in the preceding 12 months, or the patient was already referred to an echocardiography by the vascular surgeons due to clinical findings or relevant history.

A medical student and a vascular ultrasonography nurse performed all FOCUS examinations following a training program comprised of e-learning,⁸ a 1-day hands-on training course and 5 days of echocardiography in a cardiology clinic supervised by certified echocardiography technicians. FOCUS was performed according to a predefined scanning protocol (Table 1) with the patient in the left-lateral position. Cine-loops were saved in Impax, AGFA Healthcare (Mortsel, Belgium), and results were stored in REDCap.^{9,10}

All patients with unknown abnormal FOCUS findings were referred to a full echocardiography with subsequent cardiologic evaluation. The distinction between normal and abnormal was predefined for all parts of the FOCUS protocol (Table 1). Further consequences of the cardiologic evaluation were decided by clinical personnel independent of the study group. In addition, all FOCUS results, normal or abnormal, were formalized in a report made available to the anesthesiologists in the electronic patient record (MidtEPJ, Systematic, Denmark).

Demographic data were obtained from the electronic patient journal (Table 2).

TABLE 2 Baseline patient characteristics

	All N = 92		All N = 92
Age, years	71 ± 9	Chronic kidney disease	16 (17.4%)
Sex, male	66 (72%)	Creatinine (mmol/l)	77.5 [66-96]
Body mass index	27.2 ± 4.7	Haemoglobin	8.6 [8-9.1]
Smoking, yes/former	81 (88%)	C-reactive protein	4 [4-8.5]
Pack years	42.2 ± 22.5	Ferritin	115 [62-208]
ASA score	2.8 ± 0.4	Diabetes mellitus (yes)	21 (22.8%)
Hypertension	75 (81.5%)	Type, 2	21 (100%)
Congestive heart failure	8 (8.7%)	COPD ^c	24 (26.1%)
NYHA I	4 (50%)	Ambulation status, assisted	11 (16.2%)
NYHA II	3 (37.5%)	Clinical Frailty Score	2 [1.0-3.0]
NYHA III	1 (12.5%)	Type of procedure	
Former AMI ^a	17 (18.5%)	EVAR/TEVAR ^d	13 (14%)
Former CABG/PCI ^b	29 (31.5%)	Supra-aortical	1 (1%)
Arrhythmia	20 (21.7%)	Open central repair	22 (25%)
Rutherford class	2 [0-3]	Peripheral surgery	28 (30%)
Cerebral infarction	9.8% (9)	PTA ^e	28 (30%)

Note: Data are presented as mean ± SD or median [interquartile range] when relevant.

Abbreviation: NYHA, New York Heart Association.

^aAcute myocardial infarction.

^bCoronary artery bypass grafting/percutaneous coronary intervention.

^cChronic obstructive pulmonary disease.

^dEndovascular aortic repair/thoracic endovascular aortic repair.

^ePercutaneous transluminal angioplasty.

The primary endpoint was the percentage of patients with previously unknown structural cardiac disease, found with FOCUS and confirmed by echocardiography, with clinical consequence defined as further diagnostic follow-up, postponement, or cancellation of surgery. Secondary endpoints were all positive and negative FOCUS results, the diagnostic and procedural consequences of positive FOCUS findings, and the number of surgical postponements.

Descriptive data were analyzed using Stata 15.0 (StataCorp, College Station, Texas) and given as numbers (percentage).

3 | RESULTS

Ninety-two patients were included (Figure 1). Twenty-five (27%) patients had received a full echocardiography within 12 months of surgery and 12 patients (13%) patients were referred to an echocardiography by the vascular surgeons; hence, FOCUS was performed in 55 (60%) patients. FOCUS revealed pathology in 12 (22%) of these patients. In five cases, findings of mainly mildly impaired ejection fraction could not be reproduced after referral for a full echocardiography, whereas seven cases of pathology were confirmed. These were mitral valve insufficiency,¹ mildly impaired ejection fraction with concomitant mitral valve insufficiency,² dilated left ventricle (62 mm),¹ dilated right ventricle (52 mm) and combined mitral valve insufficiency,¹ aortic valve insufficiency,¹ and impaired tricuspid annular plane systolic

excursion of 16 mm.¹ All valve abnormalities were evaluated to be clinically insignificant by the cardiology specialists. The surgical procedure was postponed in a single patient with ejection fraction of 30% to 40%, and, following a coronary angiography not leading to additional intervention, the patient underwent uneventful vascular surgery. In the other patients referred for additional echocardiographic evaluation, the surgical procedures were carried out with no further delay or diagnostic workup.

4 | DISCUSSION

Despite prospective enrolment and accountability for all patients in the study period, we found that routine FOCUS prior to elective vascular surgery revealed a very low prevalence of unknown, clinically important, structural or functional cardiac disease.

The prevalence of unknown cardiac disease was dependent on characteristics of the cohort found eligible for vascular surgery. As surgical indications were in accordance with relevant guidelines from the European Society of vascular surgery, this likely did not hamper the external validity of our study. However, the availability of formalized echocardiography in a broad medical context differs internationally. Hence, a more difficult access to echocardiography regardless of indication may have reduced the fraction of patients with echocardiography performed within the preceding year, that were not eligible

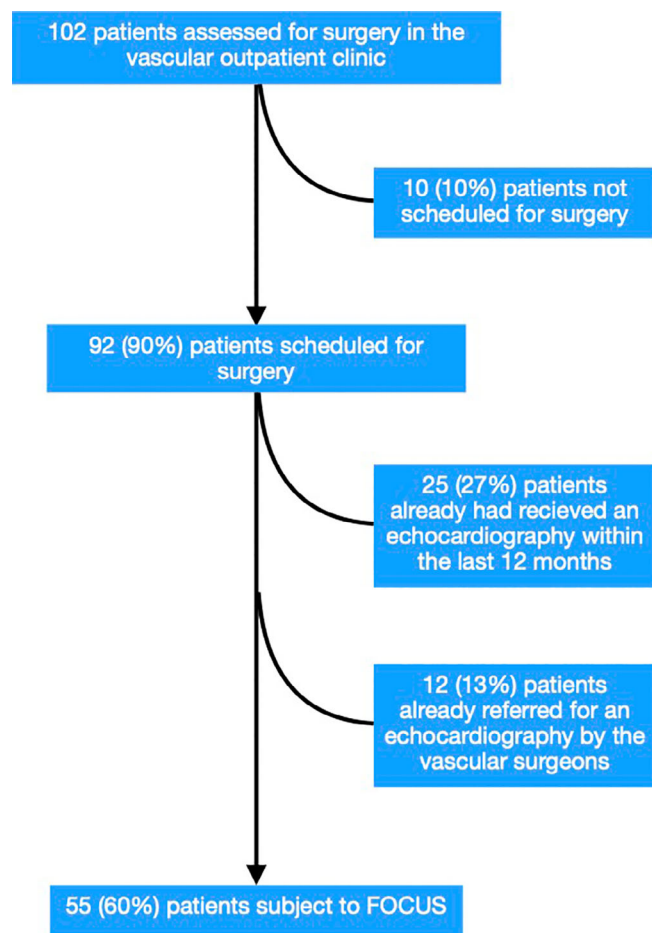


FIGURE 1 Participant flow diagram

for preoperative FOCUS evaluation. Further, part of our cohort was referred to cardiological evaluation by the attending surgeons and was not subject to FOCUS. Although guidelines for echocardiography referral exist, vascular surgeons' attention to the patients' functional capacity and other patient-related factors that can be difficult to quantify may be more or less pronounced.¹¹

The low prevalence of undetected heart disease in our cohort challenges the cost-effectiveness of routine preoperative FOCUS of all vascular patients, despite the known and high perioperative risk of cardiovascular adverse events.^{1,3,12} This favors the use of FOCUS in patients clinically suspect of cardiac disease and not as a screening tool, in concurrence with current guidelines.¹¹ However, clinical suspicion of cardiac disease often arises from diminished exercise capacity, which can be exceedingly difficult to evaluate in patients with peripheral vascular disease and limited mobility. Therefore, many vascular surgery patients are to receive a preoperative echocardiography according to current guidelines if followed strictly.¹¹

No previous studies have systematically described both the normal and abnormal cardiac ultrasonographic characteristics of vascular surgery patients, and screening for structural heart disease is not part of the recommended preoperative evaluation.¹³ We did not assess postoperative morbidity or mortality, but given that only one of 55 patients had unknown, moderate cardiac disease, our study does

not support that unknown structural and functional heart disease plays a major part in the established association between vascular surgery, postoperative myocardial injury, and major adverse outcomes including ischemic events and death.¹ Although a causal relationship between perioperative hypoperfusion of vital organs, postoperative myocardial injury, and poor outcome has not been proven,^{14,15} our results underscore the knowledge gap faced by both surgeons and clinicians as to how or if perioperative treatment can be optimized for better patient outcome.

Several observational studies have shown that FOCUS revealed cardiac pathology of relevance to anesthesiology strategy. Bøtker et al revealed unexpected pathology in 27% of patients scheduled for urgent orthopedic or abdominal surgery leading to changes in anesthesia technique or other means of patient treatment in 43% of cases. The finding of unexpected pathology was associated with 30-day mortality.¹¹ Canty et al screened 100 patients aged >65 years or who were suspect of cardiac disease from a wide range of surgical specialties during a preoperative visit. They found significant cardiac pathology in 31 patients, and, overall, anesthesia plans were changed in 54 patients. Only four patients were referred for further cardiological evaluation.^{6,7,16} However, vascular surgery patients comprised only a small part of these patient cohorts. Further, the impact of FOCUS on patient outcome remains unclear, but this is currently being addressed in a randomized multicenter study.¹⁷

This study addressed FOCUS findings and the diagnostic and logistical consequences of ultrasonography performed during the preoperative visit in the outpatient clinic for elective vascular patients. No previous study has systematically described how positive FOCUS findings impact on subsequent cardiological evaluation, additional diagnostics, and time of surgery. Of the 12 patients with positive FOCUS results who were referred for further cardiological evaluation, surgery was only postponed in a single patient. Hence, screening for structural cardiac pathology is possible in the outpatient clinical with little effect on patient flow.

This study has several limitations. We described FOCUS findings in a relatively small cohort at a single surgical center, both which may reduce external validity. Further, we did not include a control group and cannot attest to similar endpoints in a cohort without preoperative FOCUS. Finally, we focused on FOCUS findings and the impact of these findings on subsequent patient flow. Hence, postoperative endpoints were not included.

5 | CONCLUSION

Our findings do not merit implementation of routine FOCUS in the vascular surgery population but support the use of current guidelines for echocardiography referral.¹¹ Negative FOCUS findings may reassure anesthesiologists of planned anesthesia strategies in patients with limited physical capabilities, and FOCUS did not delay the time to surgery. However, larger studies are warranted to further evaluate the efficiency of preoperative FOCUS in a larger sample size.

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CONFLICT OF INTEREST

None.

AUTHOR CONTRIBUTIONS

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All authors have read and approved the final version of the manuscript.

Peter Juhl-Olsen had full access to all of the data in the study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

TRANSPARENCY STATEMENT

The authors state that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request. The available data include individual participant data, study protocol, statistical analysis, and analytic code.

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