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

Camilla Mensel1 | Nikolaj Eldrup2 | Vibeke Guldbrand3 | Peter Juhl-Olsen1

1Department of Anaesthesiology, Aarhus University Hospital, Aarhus, Denmark
2Department of Vascular Surgery, Copenhagen University Hospital, Copenhagen, Denmark
3Department of Cardiology, Aarhus University Hospital, Aarhus, Denmark

Correspondence
Peter Juhl-Olsen, Department of Anaesthesiology, Aarhus University Hospital, Palle Juul-Jensens Boulevard 99, Aarhus N 8200, Denmark.
Email: peter.juhl-olsen@clin.au.dk

Funding information
Pharmacosmos

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.3,4 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
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).
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).

### 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%) 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.

### 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. In the other patients referred for additional echocardiographic evaluation, the surgical procedures were carried out with no further delay or diagnostic workup.
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 anesthesiology 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 clinic 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.
ACKNOWLEDGMENTS
The supporting source had no involvement in study design, writing of
the report, or the decision to submit the report for publication.

CONFLICT OF INTEREST
None.

AUTHOR CONTRIBUTIONS
Conceptualization: Camilla Mensel, Nikolaj Eldrup, Peter Juhl-Olsen
Data Curation: Camilla Mensel, Nikolaj Eldrup, Peter Juhl-Olsen
Formal Analysis: Camilla Mensel, Nikolaj Eldrup, Peter Juhl-Olsen
Funding Acquisition: Camilla Mensel, Nikolaj Eldrup
Investigation: Camilla Mensel, Nikolaj Eldrup, Peter Juhl-Olsen
Methodology: Camilla Mensel, Nikolaj Eldrup, Vibeke Guldbrand, Peter Juhl-Olsen
Project Administration: Camilla Mensel, Nikolaj Eldrup, Peter Juhl-Olsen
Resources: Nikolaj Eldrup, Vibeke Guldbrand, Peter Juhl-Olsen
Supervision: Nikolaj Eldrup, Vibeke Guldbrand, Peter Juhl-Olsen
Writing—Original Draft Preparation: Camilla Mensel, Nikolaj Eldrup, Peter Juhl-Olsen
Writing—Review & Editing: Camilla Mensel, Nikolaj Eldrup, Peter Juhl-Olsen

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.

ORCID
Camilla Mensel https://orcid.org/0000-0002-9528-2578
Peter Juhl-Olsen https://orcid.org/0000-0003-1951-9091

REFERENCES
1. Biccard BM, Scott DJA, Chan MTV, et al. Myocardial injury after
non-cardiac surgery (MINS) in vascular surgical patients: a prospective
observational cohort study. Ann Surg. 2018;268(2):357-363.
2. Canty DJ, Heiberg J, Yang Y, et al. Pilot multi-centre randomised trial
of the impact of pre-operative focused cardiac ultrasound on
mortality and morbidity in patients having surgery for femoral neck
fractures (ECHONOF-2 pilot). Anaesthesia. 2018;73(4):428-437.
3. Gillmann HJ, Meinders A, Grohennig A, et al. Perioperative levels and
changes of high-sensitivity troponin T are associated with cardiovas-
cular events in vascular surgery patients. Crit Care Med. 2014;42(6):
1498-1506.
4. Heiberg J, El-Ansary D, Canty DJ, Royse AG, Royse CF. Focused echocar-
diography: a systematic review of diagnostic and clinical decision-making
in anaesthesia and critical care. Anaesthesia. 2016;71(9):1091-1100.
5. van Waes JA, van Klei WA, Wijesundara DN, van Wolfswinkel L,
Lindsay TF, Beattie WS. Association between intraoperative hypoten-
sion and myocardial injury after vascular surgery. Anesthesiology.
2016;124(1):35-44.
6. Canty DJ, Royse CF, Kilpatrick D, Bowman L, Royse AG. The impact
of focused transthoracic echocardiography in the pre-operative clinic.
Anaesthesia. 2012;67(6):618-625.
7. Batker MT, Vang ML, Grafte T, Kirkegaard H, Frederiksen CA,
Sloth E. Implementing point-of-care ultrasonography of the heart and
lungs in an anesthesia department. Acta Anaesthesiol Scand. 2017;61
(2):156-165.
8. USabcd ApS. Ultrasound Airway Breathing Circulation Dolor 2017.
https://usabcd.org
9. Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG.
Research electronic data capture (REDCap)—a metadata-driven meth-
odology and workflow process for providing translational research
informatics support. J Biomed Inform. 2009;42(2):377-381.
10. Harris PA, Taylor R, Minor BL, et al. The REDCap consortium: building
an international community of software platform partners. J Biomed
Inform. 2019;95:103208.
11. Kristensen SD, Knudt J, Saraste A, et al. 2014 ESC/ESA guidelines on
non-cardiac surgery: cardiovascular assessment and management: the
joint task force on non-cardiac surgery: cardiovascular assessment
and management of the European Society of Cardiology (ESC) and
the European Society of Anaesthesiology (ESA). Eur Heart J. 2014;35
(35):2383-2431.
12. Devereaux PJ, Duceppe E, Guyatt G, et al. Dabigatran in patients with
myocardial injury after non-cardiac surgery (MANAGE): an interna-
tional, randomised, placebo-controlled trial. Lancet. 2018;391(10137):
2325-2334.
13. Duncan D, Wijesundara DN. Preoperative cardiac evaluation and
management of the patient undergoing major vascular surgery. Int
Anesthesiol Clin. 2016;54(2):1-32.
14. Sessler DI, Khanna AK. Perioperative myocardial injury and the con-
tribution of hypotension. Intensive Care Med. 2018;44(6):811-822.
15. Sauge B, Sessler DI. Perioperative blood pressure management. Anes-
thesiology. 2021;134(2):250-261.
16. Canty DJ, Royse CF, Kilpatrick D, Williams DL, Royse AG. The impact
of pre-operative focused transthoracic echocardiography in emer-
gency non-cardiac surgery patients with known or risk of cardiac dis-
ease. Anaesthesia. 2012;67(7):714-720.
17. Pallesen J, Bhavsar R, Fjølner J, et al. The effects of preoperative
point-of-care focused cardiac ultrasound in high-risk patients: study
protocol for a prospective randomised controlled trial. Danish Med J.
2020;67(1):A07190410.