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Pre-operative transthoracic echocardiography in ambulatory surgery—A cross-sectional study

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Background: Cardiac disease and aberrations in central volume status are risk factors for perioperative complications, and should be identified prior to surgery. This study investigated the benefit of transthoracic echocardiography (TTE) for pre-operative identification of cardiac disease and hypovolemia in ambulatory surgery.

Methods: Ninety-six patients, with a mean age of 63.5 ± 12.2 years and body mass index of 27.0 ± 4.3 kg/m^2, scheduled for ambulatory surgery (breast, thyroid, and minor gastrointestinal), were consecutively enrolled in this prospective observational study. Pre-operative comprehensive TTE was performed in order to assess heart failure (HF), asymptomatic left ventricular dysfunction, valvular disease, and aberrations in central volume status.

Results: Pre-operative TTE identified a total of 28 cases of HF, 13 cases of HF with reduced or moderately reduced, ejection fraction (EF), and 15 cases of HF with preserved EF. Furthermore, 46 cases of asymptomatic left ventricular (LV) dysfunction were identified. 44/96 patients were hypovolemic, 16 of whom in severe hypovolemia. Seven cases of previously unknown obstructive valvular or myocardial disease and six cases of right ventricular systolic dysfunction were identified. A total of 24% (23/96) were classified as potential critical hemodynamic findings. The number needed (NNT) to treat for pre-operative TTE in order to find one critical finding was 4.2.

Conclusion: In this ambulatory surgical cohort, a high prevalence of pre-operative LV dysfunction and aberrations in volume status was observed. The results demonstrate that pre-operative TTE contributed valuable hemodynamic information. The standard pre-operative assessment for this cohort might need to be revised.

1 | INTRODUCTION

The population is increasing, as is the average age and thus the need for surgery. Ambulatory surgery accounts today for 60%-70% of all surgery, and the proportion is increasing in a variety of surgical procedures.[1] There is no strict age or comorbidity limit, thus challenging the perioperative management.[2,3] Symptomatic cardiac disease is an acknowledged leading risk factor for perioperative complications in non-cardiac surgery.[4–6] Furthermore, recent data suggest that not only symptomatic, but also asymptomatic left ventricular (LV) dysfunction is a risk factor for perioperative decompensation and associated with increased morbidity and mortality in elective non-cardiac[7] and major vascular surgery.[8] Hence, pre-operative risk stratification, cardiovascular optimizing, and an individualized anesthesia plan should be established for all patients with cardiovascular disease.[5,6] Nonetheless, the pre-operative assessment may fail to identify patients at risk.[9,10] Clinical evaluation of a patient's hemodynamic state may be unreliable due to inadequate/incomplete history, lack of medical records, time constraints as well as complicating comorbidities. Consequently, anesthesiologists are frequently required to proceed to surgery without up-to-date hemodynamic information.

Pre-operative transthoracic echocardiography (TTE) enables an individualized anesthesia management by establishing current central volume status (eu/hypo/hypervolemia) as well as cardiac disease prior to surgery[11,12]). Pre-operative TTE has been demonstrated to contribute valuable hemodynamic information for perioperative management in emergency surgery,[13] major non-cardiac surgery,[14,15] bariatric,[16,17] and thoracic surgery[18] with suspected cardiac disease. To our knowledge, the value of pre-operative TTE has not been previously evaluated in an ambulatory setting, hence the prevalence of previously unknown cardiac disease and aberrations in central volume status immediately prior to surgery is unclear. Thus, the aim of this study was to quantify the number of patients with cardiac disease and/or pre-operative low level of venous return at the day of surgery.

Editorial Comment

In this prospective cohort study, patients undergoing ambulatory surgery received a thorough transthoracic echocardiography pre-operatively. The study found that a quarter of all patients screened had an echocardiographic finding that might negatively influence hemodynamics. While it is unlikely that all of these findings increased the risk of harm in ambulatory surgery with minimum volume shifts, the findings still should encourage anesthesiologists to consider doing a focused pre-operative echocardiographic examination in patients at risk for adverse outcomes.

2 | METHODS

2.1 | Ethics

Ethical approval (Dnr 2016/316-31) was provided by the Regional Ethical Board in Umeå (Sweden) and written informed, signed consent was obtained from all individuals participating in the study. The study was registered prior to patient enrollment at clinicaltrials.gov (NCT03349593, Principal investigator: Tomi Myrberg, Date of registration: 21 November 2017). The collection of data was carried out between 1 December 2017 and 30 November 2018 at Sunderby hospital, Luleå, Sweden.

2.2 | Study population

One hundred and thirty individuals, ≥18 years of age, with a body mass index <35 kg/m^2, scheduled for ambulatory surgery (breast cancer, thyroidal, or gastrointestinal surgery) were consecutively assessed for eligibility for the study. The first patient every study day was excluded due to surgery flow (n = 30). After enrollment and signed consent (n = 100), four individuals were excluded due to a poor TTE-acquisition quality. Thus, the statistical analysis was conducted on 96 individuals. The study logistics are summarized in Figure 1.

2.3 | Study protocol

Transthoracic echocardiography was performed on all patients at the pre-operative day-care unit, within 2 hours before anesthesia induction. Standard over-night 6 hours minimum fasting and clear fluids were allowed until 2 hours before surgery. Patient history, current medications, and standard pre-operative laboratory tests were collected from the medical records. Patient history, with focus on exercise tolerance, history of dyspnea, and/or orthopnea, was gathered. Non-invasive blood pressure was measured in supine position with a proper-sized cuff. A venous cannula was placed in a forearm and standard blood samples, in addition to those for biomarkers of myocardial damage (high-sensitive troponin I) and

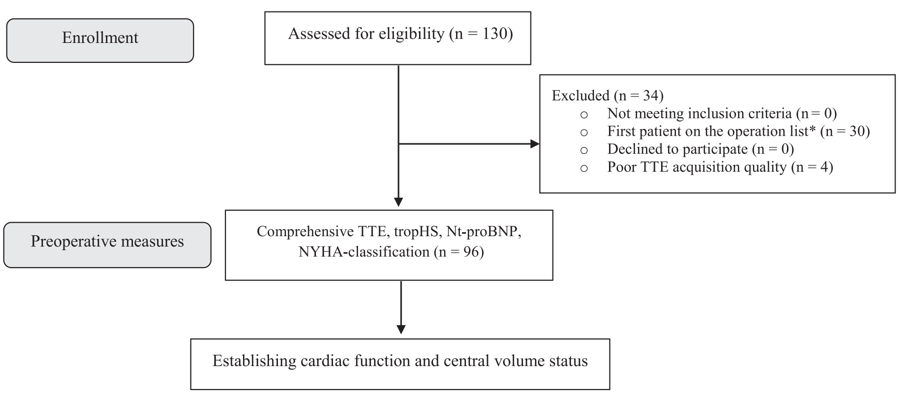

FIGURE 1 The study flow diagram and pre-operative measures. Abbreviations: *, The first patient every study day was excluded due to the surgery flow; TTE, transthoracic echocardiography; tropHS, high-sensitive troponin; Nt-proBNP, N-terminal prohormone of brain natriuretic peptide; NYHA, New York Heart Association functional classification

dysfunction (N-terminal prohormone of brain natriuretic peptide, Nt-proBNP), were collected. Revised cardiac risk index (RCRI) and classification according to the New York Heart Association (NYHA) Functional Classification were defined for each patient.

2.4 | Echocardiographic protocol

All measurements were performed by a sonographer (LL) and a clinical cardiac physiologist/anesthesiologist (TM) accordingly to current guidelines.[19,20] Heart function was classified using current recommendations established by the European Society of Cardiologist (ESC 2016).[21] A comprehensive two-dimensional TTE was performed with a GE's Vivid S70 ultrasound scanner and multifrequency transducers (M5Sc). Data were analyzed off-line by a scanner-built-in standard software (EchoPac version 113, GE Healthcare). Three consecutive end-expiratory cardiac cycles were recorded, and the mean values were used for statistical analysis. Biplane LV volume and ejection fraction (EF) were measured by the automatized GE software ("auto-EF") from apical four (4Ch) and two-chamber (2Ch) windows. Biplane left atrium (LA) volumes were traced from 4Ch and 2Ch. Conventional and tissue Doppler (TDI) were, respectively, measured to calculate transmitral E-velocity and mean e′-velocity (septal and lateral annulus). The parameters used to classify filling pressures and diastolic function of LV were: mean E/e' ratio ≥14, E/A 0.8-2, and/or positive Valsalva, and/or dilated LA, and/or tricuspid regurgitation >2.8 m/s. Pseudo-normalization and/or restrictive diastolic function were classified as "decreased compliance of LV". RV systolic function was assessed by Tricuspid Annular Plane Systolic Excursion (TAPSE), and/or longitudinal systolic maximum velocity obtained by TDI (Sm), and/or fractional area change. Moreover, TDI-derived right ventricular performance index was calculated[19]. Level of venous return and estimation of right atrium pressure (eRAP) were assessed by combining maximum diameter of the inferior vena cava (IVCmax), inferior vena cava minimum diameter (IVCmin) during "inspiratory sniff", and inferior vena cava collapsibility index (IVCCI). IVCCI was calculated by a standard equation (IVCmax–IVCmin)/IVCmax. IVC diameters were measured with 2D from subcostal windows perpendicular to the IVC's long-axis, approximately 2 cm from the junction of the IVC and the right atrium. The individuals in the study were categorized into hypovolemic, euvolemic, or hypervolemic based on IVCmax diameters and IVCCI values. Severe hypovolemia was defined as IVC < 15 mm and IVCCI > 80%. These echocardiographic measures were converted to eRAP based on the established praxis[19,22] (Table 2).

2.5 | Statistics

The sample size of the study was calculated to a minimum of 93 subjects according to the expected prevalence of a low level of venous return of 40%, α level of 0.05, and a power of 0.8 (Power = 1-β = 0.8). SPSS (IBM Corp. Released 2019. IBM SPSS Statistics for Macintosh, Version 26.0: IBM Corp.) was used to analyze the data. Chi-square/Fisher's exact test was used for comparison of binominal data. The Levene's test was applied for equality of variances and the Student's *t* test was used for comparisons of mean values. $P < .05$ were considered statistically significant.

TABLE 1 Overall patient characteristics, comorbidities with pre-operative diagnosis, and regular medications (n = 96)

Characteristics	Number of cases, mean value ± SD
Age in years (n = 96)	63.5 ± 12.3
25-40 y	6/96
41-64 y	40/96
65-74 y	35/96
75-85 y	15/96
ASA-PS (n of I, II, III)	27/41/28
Revised cardiac risk index (n of I, II, III)	16/16/6
Smoker	22/96
Metabolic equivalent of task (MET) < 4	25/96
Dyspnea in anamnesis	27/96
Hemoglobin (g L^{-1})	134 ± 15
Creatinine (μmol L^{-1}) and eGFR (ml/min/1.73 m^2)	87 ± 92, 70 ± 19
Nt-proBNP (ng L^{-1})	300 ± 510
High-sensitive troponin (ng L^{-1})	6.8 ± 5
Comorbidities with pre-operative diagnosis	
Hypertension	68/96
Ischemic heart disease	17/96
Heart failure (pre-echo)[a]	14/96
Diabetes mellitus	9/96
Bronchial asthma	17/96
Chronic obstructive pulmonary disease	12/96
Renal failure	21/96
Medication	
Beta-blockers	33/96
ACE/ARB	17/96, 20/96
Calcium channel blockers	24/96
Diuretics	26/96
Nitroglycerine	9/96
Combination therapy[b]	36/96

Abbreviations: ACE/ARB, angiotensin-converting enzyme inhibitors/angiotensin receptor blockers; ASA-PS, American Society of Anesthesiologists Physical Status score; eGFR, estimated glomerular filtration rate based on creatinine; Nt-proBNP, N-terminal prohormone of brain natriuretic peptide; SD, standard deviation.
[a]Pre-echo, before the study transthoracic echocardiography.
[b]Beta-blockers, ACE and/or ARB, calcium channel blockers, diuretics.

2.6 | Inter- and intra-observation variability

Reproducibility of echocardiographic data was assessed by reanalysis of 13 randomly selected cases. These cases were chosen for

TABLE 2 Overall transthoracic echocardiography hemodynamic findings (number of cases and % of overall, n = 96)

Heart failure and LV dysfunction	Number of cases, (%)
Heart failure	28/96 (29)
HFrEF	4/28 (14)
HFmrEF	9/28 (32)
HFpEF	15/28 (54)
Asymptomatic systolic LV dysfunction (EF < 50%)	8/96 (8)
Asymptomatic diastolic dysfunction	42/96 (44)
Mild/Isolated diastolic dysfunction	11/42 (26)
Moderate/Pseudo-normalization	28/42 (67)
Restrictive diastolic dysfunction	3/42 (7)
LV increased filling pressures	42/96 (44)
RV dysfunction	6/96 (6)
Biventricular failure	5/6 (83)
RV dysfunction + HFpEF	1/6 (16)
Level of venous return	
Severe hypovolemia (eRAP −3 to 0 mm Hg)	16/96 (18)
Moderate hypovolemia (eRAP < 5 mm Hg)	28/96 (29)
Euvolemia (eRAP 5-10 mm Hg)	45/96 (47)
Hypervolemia (eRAP > 10 mm Hg)	7/96 (7)
Combination of hypovolemia and decreased compliance of LV[a]	23/96 (24)

Abbreviations: eRAP, estimation of right ventricular pressure based on inferior vena cava measurements; HFmrEF, heart failure with moderately reduced ejection fraction; HFpEF, heart failure with preserved ejection fraction; HFrEF, heart failure with reduced ejection fraction; LV, left ventricle; RV, right ventricle.

[a]Decreased compliance of LV by definition: restrictive and/or pseudo-normalization.

reassessment after at least 1 month from the first TTE assessment. Both intra- and inter-observation variability were calculated by the equation: Variability% = (m1-m2)/(m1 + m2)/2 × 100%, where m1 and m2 are, respectively, the mean values of the first and the second measurement sets of one investigator (intra-observation variability) or the first measurement set between the two investigators TM and LL (inter-observation variability). The variables tested were LV outflow track velocity time integral, LV E, septal LV e', and IVCmax. The inter-observation variability (%) for these variables was 3.6, 3.3, 4.4, and 1.7, while the intra-observation variability for TM was, respectively, 3.9, 2.1, 0, and 3.9.

3 | RESULTS

Ninety-six individuals, with a mean age of 63.5 ± 12.3 years (range 26-85) and body mass index 27.0 ± 4.3 kg/m^2, were scheduled for ambulatory breast cancer surgery (61), reconstructive (plastic) surgery (4), thyroidal surgery (16), or minor abdominal surgery (15). In breast cancer surgery, two patients received pre-operative chemotherapy. No pre-operative radiotherapy was applied. One third of the study population was over 70 years old, and 84/96 were women. Patient characteristics and comorbidities are summarized in Table 1 and differences between male and female patients are reported in Table 4.

3.1 | Previously known cardiac dysfunction

Based on medical records of the last 5 years before surgery, 14 patients had a diagnosis of heart failure (HF). Ten of these were defined as HFrEF and one as a RV failure, while for the remaining three cases the type of HF was not mentioned. Diastolic function was known only in one patient. During this 5-year period, TTE and/or transesophageal echocardiography had been conducted in 25/96 patients, and approximately one-third (29/96) of the patients had been investigated with a cardiac modality (exercise test, spiroergometry, single-photon emission computed tomography, stress-echocardiography, percutaneous coronary investigation, or Nt-proBNP).

3.2 | Cardiac findings after pre-operative echocardiography

No pathological cardiac findings were observed in individuals younger than 40 years. However, pre-operative screening with TTE and focused history revealed a substantially increased number of cardiac concerns, especially in patients over 65 years of age. TTE screening identified four cases of HFrEF (EF < 40% + NYHA II-IV), nine cases of HFmrEF (EF41%-50% + NYHA II-IV), and eight cases of asymptomatic systolic LV dysfunction (EF 41%-50% + NYHA 0-I). Further, 15 previously unknown cases of HFpEF (EF > 50% + NYHA II-IV + echocardiographic diastolic dysfunction + pathological Nt-proBNP > 125 g/L) and 37 additional cases of grade II (pseudo-normalization, n = 28) or grade III (restrictive, n = 9) diastolic dysfunction were identified. In addition, six cases of RV dysfunction were identified (five biventricular HF and one case with RV failure + HFpEF). Further, three new cases of aortic stenosis (Vmax > 3.5 m/s, max gradient > 50 mm Hg), one of moderate mitral valve stenosis, two hypertrophic obstructive cardiomyopathies, and one case of systolic anterior motion of the mitral valve (SAM) were found. One case of pulmonary arterial hypertension was also detected (systolic pulmonary artery pressure > 35 mm Hg). High filling pressures in LV were observed in 42/96 (44%) of the study individuals. Overall, HF (P = .047) as well as asymptomatic LV dysfunction (P = .006), but not HFpEF (P = .5), were more common in patients over 65 years of age. A significant correlation between LV dysfunction and low metabolic equivalent (MET < 4) was found (Pearson's r = 0.375, P < .001). In addition, individuals with low metabolic equivalent of task (MET) were older compared to ordinary MET, 70 ± 10 vs 61 ± 12 years, respectively (P = .002). Patient echocardiographic cardiac findings are summarized in Tables 2, 3, and 4.

3.3 | Central volume status

Altogether, 44/96 (46%) patients were found to be hypovolemic based on the IVC and IVCCI measures mentioned above. Of these, 16/44 (36%) were in severe hypovolemia. Euvolemia and hypervolemia were established in 45/96 (47%) and 7/96 (7%) patients, respectively. Prevalence of hypovolemia decreased (P = .044) and LV high filling pressures increased (P < .001) with age. The data of central volume status are summarized in Tables 2, 3, and 4.

Overall, in this non-selected ambulatory surgery cohort, we found previously unknown pathologies with a potential impact on perioperative hemodynamic stability in 23/96 (24%) individuals. These findings were severe hypovolemia (n = 16) in addition to the obstructive structural valve and myocardial pathologies mentioned above (n = 7). Based on these cases, the number needed to treat (NNT), that is efficacy of pre-operative TTE, to identify one potential major hemodynamic concern was 4.2. In addition, the NNTs for low level of venous return, significant LV compliance problems (restrictive diastolic function or pseudo-normalization), and HF were, respectively, 2.2, 12.5, 1.8, and 2.5.

4 | DISCUSSION

In this unselected cohort with ambulatory surgical patients, we identified a substantial number of previously unknown cases of cardiac disease, especially in patients over 65 years of age. Low MET was found to correlate with LV dysfunction. In addition, individuals with low MET were elderly. Further, a high prevalence of asymptomatic LV dysfunction, also at an increased perioperative risk[7,8], was observed at 40-65 years of age. Valuable information on central volume status was obtained for all patients, and almost one half was hypovolemic. Transthoracic echocardiographic screening of IVCmax and collapsibility index (respiratory dynamics of IVC) seems to be useful perioperatively. In the recent study by Zhang et al,[23] both IVCmax and collapsibility index were found be good predictors for perioperative hypotension after anesthesia induction indicating that pre-operative volume depletion may exist. Systolic as well as diastolic LV dysfunction are well-recognized risk factors for perioperative adverse outcome, and should be identified prior to surgery.[4,5,7,24] Aortic stenosis, a common disease in the elderly population, is also a major risk factor and may be missed by clinical examination.[25,26] In this study, three previously unknown cases of moderate aortic stenosis were identified. The high amount of cardiac pathology in this cohort may reflect the large proportion of women over 50 years of age, a majority with a pre-existing diagnosis of hypertension, and undergoing surgery due to breast cancer, a disease associated with an increased risk for cardiovascular disease.[27]

In the pre-operative clinic, cardiac function as well as central volume status are frequently unknown, and pathology is often underestimated.[4] This may compromise perioperative hemodynamic stability and increase the rate of complications.[4,25,28] The significant impact of focused pre-operative TTE has previously been described.[14,17,18,24] Pre-operative identification of high-risk patients

TABLE 3 Characteristics, hemodynamic, and echocardiographic findings (number of cases or mean values ± SD), overall and in individuals under and over 65 years of age

Parameter	Overall	Age <65 y (n = 46)	Age ≥65 y (n = 50)	T/χ^{2a}/ Fisher[b]
Overall heart failure	28/96	9/46	19/50	P = .047[a]
Asymptomatic systolic LV dysfunction	8/96	1/46	7/50	P = .006[b]
HFpEF	15/96	6/46	9/50	P = 0.5[a]
High filling pressures in left ventricle	42/96	10/46	32/50	P < .001
Low level of venous return	44/96	26/46	18/50	P = .044
Nt-proBNP (ng L^{-1})	301 ± 510	144 ± 225	445 ± 643	P = .003
Mean arterial blood pressure (mm Hg)	107 ± 14	107 ± 13	107 ± 15	P = .92
Heart frequency	70 ± 12	69 ± 10	70 ± 13	P = .83
Stroke volume of left ventricle (mL)	63 ± 13	63 ± 12	63 ± 14	P = .96
Cardiac index (L/m^2)	2.3 ± 0.4	2.3 ± 0.4	2.3 ± 0.5	P = .54
Ejection fraction of left ventricle (%)	55 ± 9	57 ± 7	54 ± 10	P = .10
Left atrium volume index (mL/m^2)	30 ± 11	25 ± 7.6	35 ± 12	P < .001
E/e' mean	11 ± 4.7	9.5 ± 3.9	13 ± 4.7	P < .001
Tricuspid annular plane systolic excursion	22 ± 3.5	23 ± 4	21 ± 3	P = .044
RV fractional area change (%)	48 ± 9	47 ± 10	49 ± 8	P = .41
RV myocardial performance index[a]	0.6 ± 0.2	0.5 ± 0.1	0.6 ± 0.2	P = .009

Abbreviations: E/e', transmitral E-velocity e´-velocity ratio; HFpEF, heart failure with preserved ejection fraction; LV, left ventricle; Nt-proBNP, N-terminal prohormone of brain natriuretic peptide; RV, right ventricle.

[a]Tissue Doppler-derived right ventricular myocardial performance index.

[b]Fischer exact test was applied due to low number of patients in the group "age <65". (n < 5).

enables an individualized anesthesia management, and may play a key role in minimizing perioperative complications.[29] Nonetheless, at present, the use of TTE in pre-operative clinical praxis is not a routine approach, and clear indications are lacking. The 2014 ESC/ESA guidelines on cardiovascular assessment in non-cardiac surgery do not recommend routine pre-operative TTE on asymptomatic patients.[6] Further, a large retrospective cohort study found that pre-operative TTE within 6 months of surgery was not associated with a reduction in mortality or length of hospital stay.[30] However, a TTE performed months before surgery, although this allows for cardiac optimization, does not provide up-to-date information regarding volume status at the day of surgery. Anesthesiologist-performed TTE seems to predict cardiac events and provide information affecting clinical decision making,[14] but the benefit regarding patient outcome is still unclear. Nevertheless, in recent meta-analysis exploring the use of perioperative ultrasound, TTE is expected to increase perioperative safety and cut complication rates.[31]

Due to future challenges of the cardiovascular epidemic and an aging population, a paradigm shift regarding pre-operative risk assessment should be considered.[3,6] Even short episodes of intraoperative hypotension are associated with worsened surgical outcome,[28] and to enable an individualized and proactive anesthesia management, at least screening of central volume status, LV dysfunction, and motion of the aortic valve should be conducted in a risk-stratified population. The study results indicate that there is no need for cardiovascular screening in younger patients (≤40 years) if case history is not suggestive for cardiac or cardiovascular diseases. However, in elderly there seems to be a point. Based on the results of this study, a proactive echocardiographic screening may have a crucial value in (a) elderly ≥65 of age, (b) those with low physical capacity, and (c) those with symptoms. This is in line with[3] recent study pointing out that HF is a major risk factor for post-operative complications and mortality even in ambulatory surgery. But significance of asymptomatic LV dysfunction remains unclear. In this

TABLE 4 Characteristics, comorbidities, hemodynamic, and echocardiographic findings (number of cases or mean values ± SD) in female and male individuals. Overall n = 96

Characteristics and comorbidities	Female (n = 84)	Male (n = 12)	T/Fischer[a]
Age in years	64 ± 11	58 ± 17	P = .26
Hypertension	61/84	7/12	P = 0.32[a]
Ischemic heart disease	15/84	2/12	P = 1.0[a]
Dyspnea in anamnesis	25/84	2/12	P = 0.5[a]
Diabetes mellitus	8/84	1/12	P = 1.0[a]
Bronchial asthma	15/84	2/12	P = 1.0[a]
Chronic obstructive pulmonary disease	11/84	1/12	P = 1.0[a]
Renal failure	18/84	3/12	P = 0.72[a]
Hemodynamic and echocardiographic findings			
Overall heart failure	25/84	3/12	P = 0.036[a]
Asymptomatic systolic LV dysfunction	6/84	2/12	P = 0.26[a]
HFpEF	14/84	1/12	P = 0.68[a]
High filling pressures in left ventricle	40/84	2/12	P = 0.04[a]
Low level of venous return	40/84	4/12	P = 0.27[a]
Nt-proBNP (ng L^{-1})	296 ± 513	330 ± 516	P = .83
High-sensitive troponin (ng L^{-1})	6.4 ± 4.9	9.3 ± 6.7	P = .08
Mean arterial blood pressure (mm Hg)	108 ± 12	98 ± 18	P = .01
Heart frequency	71 ± 11	61 ± 12	P = .003
Stroke volume of left ventricle (mL)	61 ± 12	77 ± 14	P < .001
Cardiac index (L/m^2)	2.3 ± 0.4	2.2 ± 0.5	P = .34
Ejection fraction of left ventricle (%)	56 ± 8	51 ± 11	P = .07
Left atrium volume index (mL/m^2)	30 ± 10	33 ± 17	P = .43
E/e' mean	12 ± 5	8 ± 4	P = .02
Tricuspid annular plane systolic excursion (mm)	22 ± 3	23 ± 4	P = .26
RV fractional area change (%)	48 ± 9	48 ± 11	P = .94
RV myocardial performance index[a]	0.5 ± 0.1	0.7 ± 0.3	P = .002

Abbreviations: E/e', transmitral E-velocity e´-velocity ratio; HFpEF, heart failure with preserved ejection fraction; LV, left ventricle; Nt-proBNP, N-terminal prohormone of brain natriuretic peptide; RV, right ventricle.

[a]Tissue Doppler-derived right ventricular myocardial performance index.

study, the number of asymptomatic systolic dysfunction is relatively low and asymptomatic diastolic dysfunction may not increase the overall risk of post-operative complications at least in minor surgery without major bleeding problems and shorter duration of surgery (ie, <2 hours). Moreover, to avoid unnecessary delay of surgery associated with pre-operative cardiology referral,[32] it may be beneficial that anesthesiologists conduct the TTE themselves, as a part of the pre-operative risk stratification.[33] Present evidence supports the need for randomized trials to further investigate patient outcome and the value of anesthesiologist-performed TTE.

4.1 | Limitations

This study has several limitations. First, the generalizability of the study results is limited due to the large proportion of women. However, the cohort is unselected, and the results implicate that in populations similar to this, pre-operative cardiovascular assessment with TTE is reasonable. In this observational study, the selection bias was minimized. The study protocol was impossible to apply on the first patient of every study day (overall 30 individuals) due to the ambulatory surgery time schedule. Thereafter, a strict consecutive enrollment was conducted and, thus, the sample can be considered truly random (Figure 1). A standard fasting time (6 hours minimum) and clear fluids were allowed until 2 hours before surgery. However, actual fasting time and/or intake of clear fluids were not registered. This may have had an impact on the results. The echocardiographic protocol was comprehensive and may not be realistic to implement in clinical praxis. A screening protocol (extended point-of-care assessment) focusing on essential hemodynamic data may be preferable.

4.2 | Educational suggestions

Ultrasound has become one of the most powerful and feasible imaging techniques in medicine. Theoretical knowledge and practical skills in at least point-of-care ultrasound should be achieved early in the career of a medical provider.[34] Even more comprehensive approaches have been described recently.[35] Certificated training programs should be integrated as a default part of relevant residency programs, and perhaps already in undergraduate medical education. Implementation of the use of ultrasound early in the medical career could increase the understanding of anatomical concepts and hemodynamics in anesthesia and intensive care, and thus contribute to patient safety.[6,36–38]

5 | CONCLUSION

In this ambulatory surgical cohort, a high prevalence of pre-operative LV dysfunction and aberrations in volume status was observed. The results demonstrate that pre-operative TTE contributed valuable hemodynamic information. The standard pre-operative assessment for this cohort might need to be revised.

AUTHOR CONTRIBUTIONS

Tomi Myrberg: This author contributed to the study design, data collection and analysis, and preparation of the article. Ylva Stenberg: This author contributed to analysis of data, study design, and preparation of the article. Linnea Lindelöf: This author helped to data collection and preparation of the article. Magnus Hultin: This author contributed to study design, interpretation of data, and preparation of the article.

DATA AVAILABILITY STATEMENT

The SPSS data files regarding this manuscript are available from the corresponding author on reasonable request.

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