



Preoperative echocardiography in patients with hip fracture: a prospective cohort study

Carlo Rostagno, MD, PhD, Camilla Tozzetti, MD

Introduction: Although clinical guidelines suggest echocardiography before surgery in patients with hip fracture, no prospective studies exist in the literature. The aim of the present investigation was to assess whether preoperative echocardiography affects time to surgery, length of hospital stay (LOS), and in hospital mortality in high-risk patients who need surgery for a hip fracture.

Material and methods: In the study entered 255 consecutive patients with hip fracture referred to a multidisciplinary hip fracture unit. Seven hundred seventeen patients referred before the implementation of routine echocardiographic examination were considered as control group. Echocardiography was performed in patients with systolic murmurs, unstable clinical conditions, recent decompensation of heart failure or hospital admission for coronary disease. Time to surgery, LOS, and in hospital mortality in patients who underwent preoperative echocardiography (high-risk group) were compared with patients who did not undergo echo (low-risk group) and with the control group.

Results: 122/255 patients underwent echocardiography. The two groups did not differ for age, sex, type or fracture, and notably time to surgery and LOS. Coronary heart disease, atrial fibrillation, and two or more comorbidities were more frequent in the echo group. Overall clinical characteristics were not different from group of patients referred before the implementation of the echocardiographic protocol but in these last patients time to surgery and LOS were significantly longer. As well in hospital mortality was not significantly different in the two groups (1.9 in echo vs. 1.7% in nonecho) but lower than in the control group (4.1%).

Conclusions: An echocardiographic guide may be useful in a high-risk group with a hip fracture to choose the proper anesthetic setting, referral for intensive care observation after surgery and, optimal medical treatment, including fluid management without delay in time to surgery.

Keywords: echocardiography, elderly, hip fracture surgery

Introduction

Progressive ageing and associated comorbidities increase the risks of postoperative complications and mortality in patients undergoing hip fracture surgery. Preoperative evaluation should allow to identify patients at high-risk of early complications (most threatened are congestive heart failure, myocardial infarction, delirium, acute kidney disease, and venous thromboembolism) in order to define the more appropriate anesthesiologic and surgical strategy and to avoid preventable in-hospital death^[1,2]. Several organizational models have been proposed to improve the clinical approach in the treatment of these patients^[3–5]. An integrated team as the hip unit fracture of our teaching hospital (including

HIGHLIGHTS

- Echocardiography before surgery is recommended by guidelines in patients with hip fracture but it is rarely performed since it may delay surgery.
- Multidisciplinary management offers the best results in patients with hip fracture.
- Bedside echocardiography may be easily performed in high-risk patients within 24 h from hospital admission.
- Echocardiographic findings help to define the postoperative setting (ward vs. ICU) and anesthesiologic strategies. These measures allow to limit in hospital mortality that is not significantly different from low-risk nonecho patients.

Department of Experimental and Clinical Medicine, University of Florence, Firenze, Italy

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*Corresponding author. Address: Department of Experimental and Clinical Medicine, University of Florence, Firenze 50134, Italy. Tel.: +39 055 794 5124. E-mail: carlo.rostagno@unifi.it (C. Rostagno).

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internal medicine specialists, cardiologist, geriatric, orthopedics, and anesthesiologists) may contribute to decrease the time from hospital admission to surgery and limit perioperative complications. ESC guidelines suggest that routine rest echocardiography may be considered (evidence class I, level B) for the evaluation of high-risk surgery patients while recommendation class I evidence level A has been provided for patients with heart failure and recommendation class I evidence level C for patients with physical signs of severe valve disease^[6]. According to SIGN guidelines echocardiography is recommended in suspected aortic stenosis^[7]; however, it is rarely applied in clinical practice since this may lead to an unacceptable delay in treatment^[8–11]. Early surgery (within 24–48 h from trauma) has in fact been demonstrated to decrease

30 days and 1-year all-cause mortality in comparison to delayed interventions (> 48 h)^[12–14].

Since January 2018, in our institution has been developed a protocol that assign to routine preoperative echocardiography high-risk patients who need hip fracture surgery (e.g. patients with previously undetected systolic murmurs, unstable clinical conditions, recent decompensation of heart failure, or hospital admission for coronary disease). Echocardiographic findings may help to choose an anesthesiologic strategy, assess the need for postoperative ICU monitoring and assess volume status to optimize fluid management in order to decrease preventable deaths. Although, as previously reported, clinical guidelines suggest echocardiography before surgery in patients with hip fracture no prospective studies exist in the literature. Therefore, in the present study, we investigated the usefulness of the above-reported protocol in patients with hip fractures. Considered that several studies reported a significant delay to surgery in patients who underwent preoperative echocardiography, the first aim of the present investigation was to evaluate whether the preoperative execution of echocardiography effectively influence time to theater. In hospital and 12 months mortality were compared with that of a low-risk group of patients, referred in the same period, who did not undergo echocardiography before surgery and with a control group of patients referred before echocardiography protocol implementation.

Material and methods

Written informed consent to treatment and the collection of clinical data for research purposes was obtained at admission. The study was conducted according to STROCCS 2021 guidelines^[15] and performed in line with the principles of the Declaration of Helsinki. The study was registered at ClinicalTrials.gov Identifier number: NCT05869396.

Between 1 January and 31 May 2018, 255 consecutive patients with hip fracture aged greater than 70 years were referred for hip fracture. The diagnosis of hip fracture was made according to the OTA classification^[16]. All patients were evaluated by a multidisciplinary hip fracture team according to a previously described protocol^[5]. Demographic data, comorbidities, and functional status before trauma were recorded. According to the hip fracture unit protocol echocardiography was performed in patients with previously unknown systolic murmurs, unstable cardiovascular clinical conditions, recent (within 6 months) decompensation of heart failure or hospital admission for coronary disease (high-risk group). Results were compared with patients without these characteristics, in whom echocardiography was not performed (low-risk group). Seven hundred seventeen patients referred to the hip fracture unit in 2016 before the implementation of the echocardiography protocol were finally considered as control group.

Echocardiographic evaluation was performed by a single operator according to the guidelines of the American Society of Echocardiography^[17]. We evaluated left and right ventricular systolic function, left ventricular diastolic indexes, the presence of regional wall motion abnormalities, the severity of valve disease, and finally the systolic pulmonary artery pressure. For statistical analysis, echocardiographic parameters were categorized according to Table 1. The patients discharged alive were followed-up for 12 months. The end points of the study were time to surgery, length of hospital stay, and finally hospital and 1-year mortality.

Table 1

Categorization of echocardiographic parameters.

Echocardiographic parameters			
Ejection fractions			
Normal	Mild depression	Depressed	Severely depressed
> 55%	41–54%	31–40%	< 30%
Diastolic function			
Normal	Abnormal		
Aortic regurgitation (semiquantitative color doppler)			
Absent	Mild	Moderate	Severe
Aortic stenosis			
None	Mild	Moderate	Severe
AVA > 1.5 cm ²	AVA > 1.5 cm ²	AVA 1–1.5 cm ²	< 1 cm ²
Mitral regurgitation (semiquantitative color doppler)			
Absent	Mild	Moderate	Severe
Pulmonary Hypertension			
None-Mild	Mild	Moderate	Severe
< 20 mmHg	20–30 mmHg	30–40 mmHg	> 40 mmHg
Right ventricular function (TAPSE)			
Normal	Mild depression	Depressed	
> 20 mm	15–20 mm	< 15 mm	
Regional LV wall motion abnormalities			
Absent	Present		

Statistical analysis

Quantitative variables are reported as mean and SD. Noncontinuous variable are reported as frequency of distribution. Statistical analysis of continuous data was performed using the Student *t*-test while noncontinuous data were compared using χ^2 test. Survival analysis was performed using two-tailed Kaplan–Meier curves. Differences between groups were compared using the Log-Rank test. A probability value of 0.05 was considered statistically significant.

Results

One hundred and twenty-two out of 255 consecutive patients underwent an echocardiographic examination. The mean age of the nonechocardiography group was 83.1 ± 7.2 in comparison to 85.4 ± 8.47 in the echo group $84 + 8$ of the control group. In Tables 2 and 3 are reported the clinical characteristics of the groups.

Atrial fibrillation, a history of coronary heart disease and heart failure were significantly more frequent in the echo group as expected according to the protocol of the study. More frequently, these patients had the association of two or more than two comorbidities at hospital admission.

Echocardiography was performed within 24 h in 93% of patients. The mean time to surgery was not significantly different in patients who underwent echocardiographic examination (2.52 ± 1.7 days in the echo group in comparison to 2.33 ± 1.4 in nonecho patients) and surgery was performed within 48 h in 71.9% of echo patients and in 72.5% of those who did not undergo examination. In the control group, only 52% of patients were treated within 48 h.

Twenty-four percent of patients had moderate to severe left ventricular dysfunction at echocardiography. Severe aortic stenosis (aortic valve area < 1 cm²) was found in 7.8%, moderate to severe mitral regurgitation in 24.5%, and finally pulmonary hypertension (systolic pulmonary artery pressure > 40 mmHg) in 28%.

Table 2
Clinical characteristics in control group, nonecho, and preoperative echo patients.

	Patients referred before echo protocol implementation (717)	Non echo (133)	Echo (122)
Sex			
Male	215	36	38
Female	502	94	84
Mean age (M + SD)	84.0 ± 8.0	83.1 ± 7.2	85.4 ± 8.5
Type of fracture			
Neck of femur	303	69	63
Perthrocanteric	300	59	55
Subthrocanteric	14	–	4
Time to surgery days (M + SD)	3.3 + 2.1 ^a	2.33 ± 1.4	2.52 ± 1.7
Surgery within 48 h from trauma	52% ^b	72.5%	71.9%

^a*P* < 0.0001 echo vs. nonecho patients.

^b*P* < 0.001 echo vs. nonecho patients.

Results of echocardiography lead to a change from standard neuraxial anesthesia to general anesthesia in 47% of patients, essentially those with severe valve disease and/or left ventricular systolic dysfunction. Only 2% of nonecho patients were treated under general anesthesia for anatomical contraindications to neuraxial treatment. The need for intensive care monitoring was 38% in echo patients versus 3% in nonecho patients. In the control group overall less than 10% of patients underwent general anesthesia.

In-hospital mortality was not significantly different between patients evaluated with an echocardiogram (1.9%), and those not subjected to an echocardiographic examination (1.7%) while it was 4.1% in the control group (Table 4). No significant difference was found in the mean length of hospital stay between the nonecho and echo group (14.4 ± 5.26 days vs. 14.9 ± 7.4, respectively). In the control group, hospitalization was significantly longer (17 + 5 days).

One-year outcome

At 1-year, mortality was 18% in patients in the nonechocardiographic group compared to 32% in patients who underwent preoperative echocardiography (*P* = 0.001).

In Table 5 the clinical characteristics of echo patients who survived and, respectively, died at 1-year of follow-up are reported.

Table 3
Comorbidities in control group, in nonecho and preoperative echo patients.

Comorbidity	Hystorical group (717)	Non echo (133)	Echo (122)	<i>P</i>
Dementia	31	23%	22.9%	n.s
Parkinson disease	5.4	7.6%	6.5%	n.s
> 2 Comorbidity	38.2	22%	48.3%	< 0.0001
COPD	9.9	8.8%	15.5%	n.s
Coronary disease	15.7	7.3%	27%	< 0.0001
Heart failure	14.7	5.8%	15.5%	0.02
Atrial fibrillation	8.6	7.3%	21.3%	0.002

COPD, chronic obstructive pulmonary disease.

At univariate analysis male sex, heart failure, dementia, preoperative functional status, and the presence of two major comorbidities were associated with higher mortality.

Among echocardiographic parameters at univariate analysis only pulmonary hypertension was associated with increased 1-year mortality (Table 5). At multivariate analysis the presence of greater than or equal to 2 major comorbidities, severe functional impairment (expressed as loss of > 3 BADL) and pulmonary hypertension were shown to be independent prognostic factors of mortality.

Discussion

Echocardiographic examination in patients who need urgent-emergency surgery may give information about volume status, thus improving management of perioperative fluid administration, left and right ventricular function, and the presence of significant valve heart disease (aortic stenosis, mitral, or tricuspid regurgitation). Finally, it may identify other conditions, for example, pulmonary hypertension, or pericardial effusion, which may influence the hemodynamic response to surgery. This information may be of pivotal relevance in frail patients who undergo a major surgical stress, leading often to a change of anesthesia strategy and to plan observation in an intensive setting^[5]. Nevertheless, major concerns for echo examination regards the possible delay in surgery in comparison to nonecho patients^[12–14]. The ESC guidelines on cardiovascular assessment in patients who need noncardiac surgery suggest transthoracic echocardiography, with a class I, level of evidence B, to limit perioperative complications in patients with poor functional capacity and/or high NT-proBNP/BNP, or if murmurs are detected^[6]. Elderly patients may have particular benefit from an echocardiographic examination since risk stratification according to functional capacity may be misleading and the risk of underestimate pre-existing heart disease is substantially higher than in a younger population. This problem is amplified when elderly patients need urgent or strictly time-dependent surgery. Hip fracture is a common condition in patients aged greater than 70 years and outcomes of surgery are closely related to the time from trauma to surgery, ideally to be performed within the first 36–48 h, therefore, time and tools for risk stratification are limited^[18]. Echocardiography in this group may offer significant information to improve perioperative management Table 6.

The aim of most of previous investigations in patients with hip fracture, following the indications of the NCEPOD report published in 2009^[7], was to exclude hemodynamic significant aortic stenosis before surgery. In a small study from Sunderland Royal Hospital patients with a new diagnosed heart murmur underwent an echocardiographic examination. Results led to a change in anesthetic strategy in 50% (general vs. neuroaxial anesthesia); however, since the examination was made by the hospital cardiology department, the execution of echocardiography led to a significant delay in time to surgery (2.7 days in comparison to 1.1 days in the nonecho group; *P* < 0.001)^[19]. Similar results have been reported by other authors^[20,21].

The implementation of different organization models that included bedside preoperative echocardiography, allow a real-time more careful preoperative evaluation. At Derriford Hospital was instituted a routine weekday bedside echocardiography service for patients with hip fracture^[10]. In patients who needed

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Table 4
Hospital mortality and length of stay in historical group, in nonecho and preoperative echo patients.

	Historical group (717)	Non Echo (133)	Echo (122)	P
Hospital mortality (%)	4.1	1.7	1.9	0.05
Length of stay (days)	17 + 5	14.4 ± 5.26	14.9 ± 7.4	0.0001

echocardiography delay in surgery decreased by about 4.7 days in comparison to the period in which patients were referred to the cardiology service.

At present, limited and controversial results have been reported regarding the impact of echocardiographic examination on clinical outcome in patients undergoing noncardiac surgery. Two large retrospective cohort studies showed that routine preoperative TTE before high-risk noncardiac surgery did not reduce the risk of postoperative MACE^[22,23]. In these studies, however, patients undergoing different surgical procedures, most elective, are included; enrollment is not limited to potential high-risk patients. Moreover, the studies differ for echo parameters examined and the length of follow-up. Therefore, results must be interpreted with caution for elderly high-risk patients. The studies in patients with hip fracture are limited to the assessment of severe aortic stenosis.

In the study by Canty *et al.*^[8] 64 high-cardiac risk patients underwent preoperative TTE and were compared to a randomized cohort who did not undergo echocardiography but similar cardiac risk generated by randomly selecting patients from the hospital surgical databases. Mortality was lower in the TTE group at 30 days (4.7 vs. 15.2%, $P = 0.047$) and 12 months after surgery (17.1 vs. 33.3%, $P = 0.031$).

Kalem *et al.*^[24] analyzed the effects of preoperative echocardiography on patient survival, timing of surgery, and length of hospital stay in patients who underwent hip nailing for an intertrochanteric fracture. In the study were included 181 patients (110 women and 71 men; mean age 81 years). Sixty-five underwent preoperative echocardiography. The time to surgery and total hospital stay was 2 days longer in the transthoracic echocardiography (TTE) group ($P < 0.001$). At 1 month, the control

group survival rate was 93.1 and 75.4% in the TTE group. One-year survival rates were 77.3 and 55.1%, respectively.

In the present investigation, bedside echocardiography was performed in a ‘high-risk’ group of patients identified on the basis of history and clinical examination (e.g. patients with previously undetected systolic murmurs, unstable clinical conditions, recent decompensation of heart failure, or hospital admission for coronary disease). These indications agree with recently published ESC guidelines that suggest as appropriate indications for TTE poor exercise tolerance, abnormal ECG, suspected new or significant cardiovascular disease without examination in the previous 3 months, unexplained dyspnea, or coexisting clinical risk factors^[6]. At least one significant abnormality was found in 98% at the echocardiographic examination. The main end point of the study was to evaluate whether echocardiography may delay time to surgery. Ninety-three percent of patients underwent echocardiography within 24 h from admission and the whole population within the second day of hospitalization. In 72% of patients surgery was performed within 48 h both in the echo and in nonecho group. Therefore, the answer to the first question is that in an organized multidisciplinary team echocardiography does not delay time to surgery. The length of the hospital stay was consequently not affected by the need for an echocardiographic examination.

Due to its design, the answer to the third end point is more difficult. We did not considered ethical randomization of high-risk patients in two different intervention group being aware that echocardiography did not delay the time to surgery. Nevertheless, hospital mortality did not significantly differ between high (echo) and low (nonecho) risk groups. The adoption of tailored anesthesiologic and clinical measures, including postoperative ICU observation when needed, according to echocardiographic findings may have limited the hemodynamic and clinical consequences of surgery and therefore hospital mortality in high-risk patients. Although neuraxial anesthesia is not an absolute contraindicated for patients with aortic stenosis or severe left ventricular dysfunction, these patients are more susceptible to the potential hazard of sudden hypotension because of the reduced systemic vascular resistance caused by the sympathetic blockade. The use of invasive arterial monitoring to provide beat-to-beat measurement and enable rapid correction of hypotension is essential to avoid potential irreversible hemodynamic derangement.

The comparison with data before the implementation of routine echocardiographic examination by our multidisciplinary hip fracture unit further support the clinical usefulness of echocardiography in high-risk patients. Infact, even if the clinical characteristics of referred patients did not change with time, the proportion of patients who underwent early surgery significantly increased, the length of hospitalization was reduced, and mortality decreased by about 40%. This may be mainly attributed to a better preoperative evaluation allowing more appropriate preoperative management.

Table 5
Clinical findings in patients underwent preoperative echocardiography alive or died at 1-year follow-up.

Clinical characteristics	Alive at follow-up (76)	Died at follow-up (43)	P
Male/Female	63/13	23/20	0.004
Type of fracture			
Neck of femur	41	22	n.s
Perthrocanteric	32	21	
Subthrocanteric	3	–	
Time to surgery <48 h	62	34	n.s
BADL < 4	13	25	0.003
Dementia	13	27	< 0.0001
Parkinson	5	7	n.s
> 2 comorbidity	28	34	0.0001
Coronary disease	14	11	n.s
Heart failure	4	21	0.003
Atrial fibrillation	22	10	n.s
COPD	14	9	n.s

BADL, basic activities daily living; COPD, chronic obstructive pulmonary disease; HF, heart failure.

Table 6
Echocardiographic findings in patients underwent preoperative echocardiography alive or died at 1-year follow-up.

	Alive at follow-up (76)	Died at follow-up (43)	P
Left atrium			
Normal	46	18	n.s
Enlarged	30	25	
Aortic regurgitation			
None -mild	49	25	n.s
Moderate	31	12	
Severe	6	6	
Aortic stenosis			
None	59	29	n.s
Mild	9	8	
Moderate	3	4	
Severe	5	2	
Mitral regurgitation			
None	42	20	n.s
Mild	28	10	
Moderate	5	3	
Severe	1	—	
LVEF %			
> 55	62	31	n.s
35–55	10	9	
< 35	3	3	
Pulmonary hypertension			
None	47	16	0.04
Mild	11	7	
Moderate	12	10	
Severe	6	10	
LV wall motion abnormalities	12	3	n.s
LV Hypertrophy	11	15	n.s.

Survival results at 1-year are not surprising; in fact, in patients who underwent echocardiography mortality was near twofolds higher in comparison to low-risk patients. Frailty expressed as a limitation of BADL and the presence of two or more comorbidities were independent risk factors in both groups. Interestingly, the only echocardiographic parameter independently related to death was pulmonary hypertension. With the limits of the small number of patients included in the study, this observation is of particular significance since pulmonary artery pressure is a comprehensive index of hemodynamic status. Whether a more accurate outpatient clinical management including, when needed, interventional or surgical treatment of valve or coronary disease could improve the long-term prognosis of high-risk patient is not known and should be a matter of study.

Limitations

The main limitation, as previously stated, is the nonrandomized design of this study, which assigned to echocardiography only patients clinically at high-risk. Historical data from our center report that before the introduction of echocardiography overall hospital mortality was 3.7 almost 40% higher in comparison to the present investigation. Considering that clinical characteristics of patients did not change in the two periods and that mortality in low-risk patients did not significantly change, it may be inferred that the advantage of multidisciplinary management that includes preoperative echocardiography is substantial. A further limit is the overall small number of patients enrolled; nevertheless, this is

one of the few prospective study published in the literature and may be the starting point for a large multicentric investigation.

Conclusions

Beside echocardiography does not delay surgery in high-risk patients who need hip fracture surgery. In hospital stay and more relevant in hospital mortality do not differ from that of a nonecho lower risk group. One-year mortality is significantly higher in the echo group reflecting the poorer preoperative conditions of these patients. Whether a more careful outpatient management after discharge may limit the high 1-year mortality in the high-risk group need further investigation.

Ethical approval

The study is part of a project of Italian Health Ministry and Regione Toscana – RF-2010-2316600- and was approved by Ethical Committee of Regione Toscana in date 17 May 2012.

Consent

Written informed consent was obtained from the patient for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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None.

Author contributions

C.R.: made contribution to design, acquisition, and analysis of data and drafting the manuscript and gave final approval; C.T.: was involved in drafting the manuscript and revised it critically.

Conflicts of interest disclosure

The authors declare no conflict of interest.

Research registration unique identifying number (UIN)

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Guarantor

Carlo Rostagno.

Data availability statement

Data may be available on request.

Provenance and peer review

Not commissioned, externally peer-reviewed.

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