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Does a delay to surgery for preoperative echocardiogram affect outcomes in patients with hip fracture?

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Abstract

Introduction: Delay to surgery >24 hours has been shown to correlate with mortality rates in patients with hip fracture when left untreated. Many of these patients have multiple comorbidities, including aortic stenosis (AS), and undergo workup for operative clearance, which may delay time to surgery. The purpose of this study was to examine whether preoperative echocardiogram workup affects time to surgery, complications, and mortality after operative fixation for hip fracture.

Methods: Our institutional hip fracture registry was retrospectively reviewed for inclusion over a 3-year period. Patients who had a preoperative echocardiogram (yECHO) for operative clearance were compared with those who did not (nECHO). Demographic data, time to surgery, overall complication rate, and mortality at 30 days, 90 days, and 1 year were collected.

Results: Two cohorts consisted of 136 yECHO patients (45.8%) and 161 nECHO patients (54.2%). Thirty-two yECHO patients (23.5%) had AS. Patients in the yECHO cohort were more likely to have a complication for any cause compared with nECHO patients (25.7% vs. 10.6%, $P = 0.01$) and have a higher mortality rate at 1 year (38.9% vs. 17.4%, $P = 0.001$). There was no association found between AS and all-cause complication ($P = 0.54$) or 30-day ($P = 0.13$) or 90-day mortality rates ($P = 0.79$). However, patients with AS had a significantly higher mortality rate at 1 year (45.8% vs. 25.1%, $P = 0.03$).

Conclusion: This study reinforces the benefits of ensuring less than a 24-hour time to surgery in the setting of a hip fracture and identifies an area of preoperative management that can be further optimized to prevent unnecessary prolongation in time to surgery. Patients with known aortic stenosis are not associated with increased 30-day or 90-day mortality or all-cause complications. Surgical delays in the yECHO cohort were attributed to preoperative medical assessments, including echocardiograms and the management of comorbidities. Therefore, the selective utilization of preoperative echocardiograms is needed and should be reserved to ensure they have a definitive role in guiding the perioperative care of patients with hip fracture.

Level of Evidence: III.

Key Words: hip fracture, preoperative echocardiogram, aortic stenosis, mortality, complications

1. Introduction

Hip fractures continue to be one of the most common orthopaedic injuries worldwide. With an ever-growing elderly population, it is estimated that the annual number of cases globally will reach 6.26 million by 2050.[1] These patients tend to have multiple comorbidities that may delay surgical intervention due to the need for preoperative medical optimization. Often, preoperative cardiac consultation is obtained for further evaluation of these patients and is the reason these delays occur.[2,3] Time to surgery has been shown to directly influence 30-day and 90-day mortality rates when hip fractures are left untreated for longer than 24 hours.[4,5] The American Heart Association (AHA) and American College of Cardiology (ACC) guidelines recommend preoperative cardiac testing when perioperative heart score for

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major cardiac events risk (MACE) is higher than 1% and metabolic equivalent (MET) <4 mL/kg/min.[6] Older studies found severe valvular heart disease to significantly increase the risk of perioperative MACE.[7] Agarwal et al reported that patients with moderate or severe aortic stenosis (AS) undergoing nonemergency noncardiac surgery had a 30-day mortality rate double that of matched patients without AS (2.1% vs. 1.0%).[8] Postoperative MI was almost 3 times as frequent in patients with AS compared with those without (3.0% vs. 1.1%; $P = 0.001$). However, Tashiro et al[9] reported that patients with truly asymptomatic severe AS and those without AS had similar MACE rates. Observational data suggest that it is reasonable to perform moderate-risk elective noncardiac surgery with appropriate intraoperative and postoperative hemodynamic monitoring in patients with asymptomatic severe AS.

The purpose of this study was to examine whether a preoperative echocardiogram in the setting of known AS affects time to surgery, rate of complication, or mortality within this patient population.

2. Methods

This multi-institutional retrospective observational study was approved by the Western institutional review board (WIRB—Protocol #:20171537; Principal Investigator: Frank A. Liporace, MD) in accordance with the Declaration of the World Medical Association (www.wma.net) prior to the initiation of our study. By protocol, written informed consent was obtained from all patients prior to their inclusion into our hip fracture quality and outcomes registry. A retrospective chart review of each hospital's hip fracture quality and outcomes registry was performed. All patients who underwent operative fixation of a femoral neck, intertrochanteric, or subtrochanteric femur fracture over a 3-year period (2017, 2018, and 2019) were identified. Patients with polytrauma were excluded. Two-hundred ninety-seven patients were included for analysis. Operative fractures analyzed included 121 femoral neck, 143 intertrochanteric, and 33 subtrochanteric femur fractures.

The patients who had a preoperative echocardiogram (yECHO) for operative clearance were compared with those who did not (nECHO). Anesthesia Society Association (ASA) score was used to determine whether patients receiving preoperative echocardiograms were sicker at baseline. Patient demographics; comorbidities; time to surgery; intraoperative and postoperative data; echocardiogram results including ejection fraction, aortic valve stenosis, and valve prolapse; and clinical outcomes including overall complication rate, inpatient mortality, and mortality at 30 days, 90 days, and 1 year were collected for comparative analysis.

2.1. Statistical Analysis

Counts (%) of categorical patient demographic and surgical variables are reported. Means and standard deviations (SD) of continuous patient demographics are reported. To test for differences in demographic and surgical variables of patients with known AS undergoing preoperative echocardiogram based on postoperative complications and mortality, chi-square tests were calculated for categorical variables and one-way analysis of variance (ANOVA) tests were calculated for continuous variables. Fisher exact tests were used in place of chi-square where appropriate. The primary outcome measured was mortality at discharge, 30 days, 90 days, and 1 year. The relationship between patients undergoing preoperative echocardiogram with all-cause complication was assessed with absolute differences (AD) and 95% confidence intervals (95% CI) using bivariate and multivariable linear regression analysis. Mortality due to preoperative echocardiogram and AS was analyzed using Kaplan–Meier survival curve analysis with log-rank test. A P-value of <0.05 was considered to be statistically significant in all calculations. All statistical analyses were performed using Stata/IC v16.1 (College Station, TX).

3. Results

A total of 136 patients (45.8%) received a preoperative echocardiogram while 161 patients (54.2%) did not (Table 1). Most patients were female (62.8%) with a mean age of 79 years. Mean time to surgery in patients in the yECHO cohort was 39.7 hours compared with 31.1 hours in nECHO cohort ($P = 0.01$). Moreover, patients in the yECHO cohort had a significantly longer length of hospital stay compared with patients in the nECHO cohort (6.7 ± 5.3 days vs. 5.3 ± 5.4 days, $P = 0.02$). In the subset of patients receiving a preoperative echocardiogram, 26 of 136 patients (19%) adhered to the AHA/ACC guidelines published in 2014. The indications for the patients meeting guidelines were as follows: 14 patients with clinically suspected moderate or greater degree of valvular stenosis or regurgitation without prior echocardiogram within the past year, 8 patients presenting with a significant change in clinical status or physical examination, 2 patients with dyspnea of unknown origin, and another 2 patients with a history of heart failure presenting with worsening dyspnea which required further evaluation of left ventricular function. Four of 26 patients (15%) who met AHA/ACC guidelines had adjustments in anesthesia technique perioperatively compared with the 16 of 136 (12%) for the entire yECHO cohort of patients who received a preoperative echocardiogram.

Of the total number of patients in the yECHO group, 35 patients (25.7%) experienced a postoperative complication compared with only 18 patients (10.6%) within the nECHO group ($P = 0.01$). The most prevalent complications were arrhythmia, respiratory failure/pneumonia, and cardiac arrest among other complications (Table 2).

Thirty-two patients (23.5%) had a history of known AS, and all of these patients received a preoperative echocardiogram prior to clearance for hip fracture surgery. Seven of those patients (21.8%) experienced a postoperative complication. One of those patients (3.1%) died within the hospital postoperatively. There was no association found between AS and postoperative all-cause complication rate ($P = 0.54$) or mortality rate at 30 days or 90 days ($P = 0.13$ and $P = 0.79$, respectively). However, patients with AS did have a significantly higher mortality rate at 1-year post-operative than patients without AS (Table 3, 45.8% vs. 25.1%, $P = 0.03$)

When factoring in ASA score to determine whether patients in the yECHO cohort were sicker at baseline, there was no difference found in complication rate based on ASA score between the 2 cohorts (Table 4, $P = 0.07$). On univariate analysis, the odds of a patient experiencing a complication were 2.91 times higher when delaying surgery for a preoperative echocardiogram ($P = 0.001$). Additionally, when controlling for ASA scores in the bivariate model, the odds were still 2.51 times higher for complications compared with patients in the nECHO group ($P = 0.007$). When further controlling for all potentially confounding variables, determined by differences in head-to-head

TABLE 1

Demographic and Perioperative Variable Comparison Between Patients Who Received Preoperative ECHOs Versus Patients Who Did Not

	nEcho	yEcho	*P*
n	161	136	
Age	**75.5 ± 14.3**	**82.6 ± 9.5**	**<0.001**
Gender	62.5% F	63.2% F	0.90
Side	56.9% R	47.1% R	0.09
Length of hospital stay (d)	**5.3 ± 5.4**	**6.7 ± 5.3**	**0.02**
Time to surgery (h)	**31.1 ± 22.7**	**39.7 ± 33.9**	**0.01**
Chronic anticoagulation	**35.5%**	**50.4%**	**0.01**
ASA			
1	**3**	**0**	
2	**63**	**17**	
3	**74**	**83**	**<0.001**
4	**15**	**33**	
5	**0**	**1**	
Aortic stenosis	**0%**	**23.5%**	**<0.001**
Diabetes	27.1%	36.8%	0.08
Pulmonary disease	16.8%	22.8%	0.20
Liver disease	3.2%	4.4%	0.60
Renal disease	**11.6%**	**24.3%**	**0.005**
Cancer	19.4%	17.6%	0.71
Smoker	17.4%	11.1%	0.13
Preoperative Ambulation	97.4% Y	94.6% Y	0.22
Race			
White	99	89	
Black	21	16	
Asian	11	12	0.38
Hispanic	6	9	
Other	0	3	
Anesthesia			
General	138	118	
Spinal	18	14	0.99
Local	1	2	
Diagnosis			
FNF	72	49	
IT Fx	68	75	
IT Fx w/ST extension	5	1	0.38
ST Fx	16	11	
Implant			
Short IMN	27	13	
Long IMN	69	73	
HHA	30	31	0.92
THA	29	13	
CRPP	6	6	
Operative time (min)	**96.5 ± 40.0**	**83.0 ± 34.4**	**0.02**
In-hospital complications			
UTI	3.9%	2.2%	0.42
Pressure ulcer	1.3%	3.7%	0.18
Pneumonia	1.3%	5.2%	0.06
Overall complications	**10.6%**	**25.7%**	**0.01**
30-d mortality	2.7%	6.6%	0.12
90-d mortality	**5.9%**	**19.3%**	**0.001**
1-y mortality	**17.4%**	**38.9%**	**0.001**

Patients with preoperative Echo had a longer length of stay and time to surgery, along with a lower complication rate. Cohorts were dissimilar in a number of demographic variables (age, ASA, chronic anticoagulation use, aortic stenosis, and renal disease).
All bolded entries represent statistical significance $P < 0.05$.
CRPP, closed reduction and percutaneous pinning; FNF, femoral neck fracture; Fx, fracture; HHA, hemi-hip arthroplasty; IMN, intramedullary nail; IT, intertrochanteric; ST, subtrochanteric; THA, total hip arthroplasty.

comparison, patients in the yECHO cohort had a 4.64 times higher odds of causing a postoperative complication (Table 5).

Overall, 53 patients (38.9%) in the yECHO cohort died within a year of the procedure compared with 28 patients (17.4%) in the nECHO cohort ($P = 0.001$). When comparing survival rates between patients receiving preoperative echocardiograms, the median survival time was significantly longer for patients in the nECHO group than patients in the yECHO group (Fig. 1A, 35 months vs. 30 months, $P = 0.04$). When comparing survival rates between patients with or without AS, there were no differences in survival rates between patients with or without AS (Fig. 1B, $P = 0.08$).

TABLE 2

A List of Complications Experienced by Patients With Hip Fracture

Complications	N
Arrhythmia	8
Respiratory failure/pneumonia	8
Cardiac arrest	6
Encephalopathy	6
Acute kidney injury	4
Fever of unknown origin	3
Postoperative ileus	3
Deep vein thrombosis	3
Elevated troponin	2
Hyponatremia	2
Pressure ulcer	2
Urinary tract infection	2
Urinary retention	2
Septic shock	2
Gastrointestinal bleed	2
Stroke/TIA	1
Hypovolemic shock	1
Metabolic acidosis	1
Head bleed	1
Delirium	1
Hematuria	1
Small bowel obstruction	1
CHF exacerbation	1

4. Discussion

The primary concern in the management of hip fractures is the risk for increased mortality and complications within the first 30 days and 90 days when hip fractures are left untreated for longer than 24 hours. Given the importance of optimizing the time to surgery, this study specifically investigated whether delaying surgery to

TABLE 3

Presence of Aortic Stenosis and Its Effect on Mortality at 30 days, 90 days, and 1-year

	yAortic Stenosis	nAortic Stenosis	*P*
Complications			0.54
No	25 (78.1%)	212 (82.5%)	
Yes	7 (21.9%)	45 (17.5%)	
Mortality			
30 d			
No	27 (90.0%)	224 (96.1%)	0.13
Yes	3 (10.0%)	9 (3.9%)	
90 d			
No	25 (86.2%)	183 (88.0%)	0.79
Yes	4 (13.8%)	25 (12.0%)	
1 y			
No	13 (54.2%)	131 (74.9%)	0.03
Yes	11 (45.8%)	44 (25.1%)	

Only one patient with aortic stenosis suffered early mortality. There was no increased mortality with aortic stenosis. Fisher exact test was used for mortality comparison, and χ^2 test was used for complications comparison.

TABLE 4

Total Complication Rate and Mortality Rate Stratified by ASA Score

	ASA					*P*
	1	2	3	4	5	
Complications						
No	3 (100%)	69 (86.3%)	130 (82.8%)	35 (72.9%)	1 (100%)	0.07
Yes	0 (0%)	11 (13.7%)	27 (17.2%)	13 (27.1%)	0 (0%)	
Total	3	80	157	48	1	
Mortality 30 d						
No	3 (100%)	73 (96.1%)	136 (95.8%)	38 (92.7%)	1 (100%)	0.47
Yes	0 (0%)	3 (3.9%)	6 (4.2%)	3 (7.3%)	0 (0%)	
Total	3	76	142	41	1	
Mortality 90 d						
No	3 (100%)	65 (94.2%)	111 (88.9%)	29 (74.4%)	0 (0%)	0.004
Yes	0 (0%)	4 (5.8%)	15 (11.1%)	10 (25.6%)	1 (100%)	
Total	3	69	126	39	1	
Mortality 1 y						
No	2 (100%)	46 (85.2%)	80 (73.4%)	16 (47.1%)	0 (0%)	<0.001
Yes	0 (0%)	8 (14.8%)	29 (26.6%)	18 (52.9%)	1 (100%)	
Total	2	54	109	34	1	

Complication rates were similar across all ASA scores. Kruskal–Wallis test was used for comparison due to the nonparametric distribution of ASA scores.

obtain a preoperative echocardiogram affects postoperative outcomes. This study found that known AS is not associated with increased mortality or complications within the first 90 days of surgery in the setting of operative fixation of proximal femur fractures. However, increased mortality rates were observed at 1-year postoperatively. Therefore, while early 90-day postoperative outcomes were not adversely affected, a judicious evaluation of each patient's individual risk may be warranted. This includes considering the potential risk of delaying hip fracture management against the benefits of obtaining preoperative echocardiograms, which may influence anesthesia techniques and other aspects of perioperative management. This information aligns with previous

TABLE 5

Univariate, Bivariate, and Multivariate Logistic Regression Analyzing the Effect of Preoperative Echocardiogram on the Outcome of Complications

Dependent Variable	OR	95% CI	*P*
Univariate			
Preoperative echocardiogram	2.91	1.55–5.49	0.001
Bivariate			
Preoperative echocardiogram	2.51	1.28–4.93	0.007
ASA score	1.22	0.76–1.97	0.41
Multivariate			
Preoperative echo	4.64	1.39–15.52	0.01
Age	0.98	0.94–1.03	0.48
Chronic anticoagulation	1.39	0.51–3.78	0.52
Aortic stenosis	1.05	0.23–4.75	0.95
Operative time	1.01	0.99–1.02	0.34
Renal disease	1.95	0.70–5.39	0.20
Diabetes	2.73	0.99–7.51	0.05
ASA score	0.95	0.46–1.97	0.90

All potential confounders were included. Confounders were determined by differences between cohorts on head-to-head comparison.

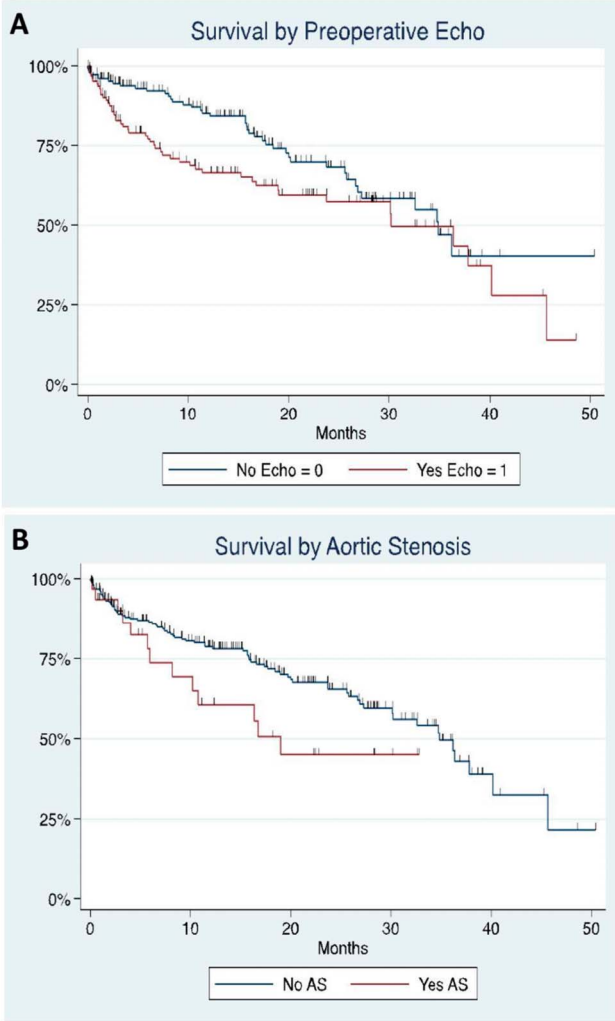

Figure 1. A. Survival curve by preoperative Echo. Log-rank test, $P = 0.04$. B. Survival curve by aortic stenosis. Log-rank test, $P = 0.08$.

studies that show the goal time for operative fixation within 24 hours of admission decrease mortality rate.[10–13] Other studies agreed with the notion that earlier time to surgery correlated to having better outcomes, but did not see any significant difference if the surgery was performed within 48 hours of admission. These studies reported an increased risk of mortality, myocardial infarction, serious bacterial infection, and decubitus ulcers in surgeries delayed beyond 48 hours.[2,5,14–16]

Our study showed that patients obtaining a preoperative echocardiogram extended their time to surgery to an average of 39.7 hours, which was ultimately associated with an increased complication rate. The nECHO group made it to surgery on average at 31.1 hours and did not confer an increased mortality or complication rate. As shown in this study, patients in the nECHO group had a significantly longer median survival time than patients in the yECHO group. Additionally, while the median survival rates for patients without AS were observed to be longer compared with those with AS, this difference did not reach statistical significance ($P = 0.08$). Despite the lack of statistical significance, this observation emphasizes the need for critically assessing and optimizing the medical clearance process prior to surgery, ensuring that only essential examinations that provide decision-making information are performed. In the case of known AS, the

preoperative echocardiogram did not affect the patient outcomes, and a small percentage of preoperative echocardiograms aligned with AHA/ACC guidelines. However, in select instances, there were echocardiograms along with the patient's clinical history which helped inform changes in anesthesia technique and perioperative care. Thus, while most echocardiograms did not require adjustments in anesthesia management, they can be an essential part of preoperative medical assessment when used with proper indications and adhering to established guidelines. More selective use of preoperative echocardiograms may streamline the preoperative process without compromising patient outcomes.

The primary principle for a preoperative echocardiogram in the setting of known AS is to determine the severity of stenosis and left ventricular function. Guidelines from the American College of Cardiology/American Heart Association define severe AS as aortic valve area $\leq$1 cm, mean gradient of $\geq$40 mm Hg, and peak velocity of $\geq$4 m/s, which labels the patient as high risk for noncardiac surgery.[17] Labeling severe AS is an outdated practice prior to surgery because it offers limited information for risk assessment and anesthesia management. Additionally, patients with severe AS had similar postoperative events, intraoperative hypotension, and perioperative myocardial rates when compared with a control group without AS.[18] AS is the most prevalent valvular disorder in the elderly, who are the primary population that have hip fractures, so if preoperative echocardiograms do not affect operative management, they should be avoided to prevent delay to surgery.[19–21] Andersson et al[22] further investigated how AS is not an independent risk factor for adverse outcomes in noncardiac surgery and is more likely attributed to the burden of comorbidities associated with the patient. This coincides with our findings that there were no increased mortality rates in patients with known AS (Table 3). It would be prudent to further research the cardiovascular conditions that predict worse patient outcomes and the most efficient methods to assess medical stability prior to operative management of orthopaedic injuries.

A prior study demonstrated that patients with severe AS have worse 30-day perioperative complications, but that can also be attributed to higher rates of comorbidities in these patients such as coronary artery disease, atrial fibrillation, pulmonary disease, and renal disease.[23] Because these patients are sicker at baseline, they may need further workup and do not apply to the predominantly ASA level II and III classified patient population in this study.

Although there is an urge to perform surgery as soon as possible, previous observations show that there are no differences in the risk of mortality or major complications for surgeries that begin at a median time of 6 hours versus 24 hours.[24] This supports the idea that surgery should not be delayed beyond 24 hours to provide the best patient outcomes but does not need to be expedited if it puts the patient at greater risk. Additionally, use of the preoperative cardiogram was associated by increased odds of complication of 4.64 when controlling for confounding factors. Nonetheless, it is essential to consider that the subset of patients who underwent preoperative echocardiograms may inherently have had higher baseline risk for postoperative complications due to comorbidities. Thus, results of this study must be interpreted with caution recognizing that the echocardiograms may have been part of a comprehensive preoperative evaluation in a more complex patient cohort. The authors' institution recognizes the importance of having an interdisciplinary quality improvement protocol in place for optimizing the management and care of geriatric patients with hip fractures. Thus, the institution is actively exploring areas to identify and implement systems that better streamline necessary preoperative evaluations to minimize delays in surgery.

This study is limited because it focuses on preoperative echocardiograms in the setting of AS; however, there may be concurrent medical conditions that warrant the need for sufficient cardiac work up to ensure patient safety under anesthesia and during the postoperative period. There are a number of comorbidities associated with AS, such as chronic kidney disease, hypertension, atrial fibrillation, and chronic obstructive pulmonary disease, which should not be overlooked in terms of medical management based on the data from this study.[25,26] Additionally, as with all retrospective analyses, some selection bias could be present due to the retrospective nature of the study. Nevertheless, in the case of known isolated AS, our study shows that surgery should not be delayed to obtain an echocardiogram. Additionally, all patients with known AS underwent preoperative echocardiogram, so we are unable to examine the mortality and complication outcomes of patients with known AS and did not have a preoperative echocardiogram performed. It is also important to note whether any surgical or anesthetic decisions were made based on the knowledge from the cardiac workup or if it only determined whether the patient was medically cleared to undergo surgery.

5. Conclusion

This study reinforces the benefits of ensuring less than a 24-hour time to surgery in the setting of a hip fracture and identifies an area of preoperative management that can be further optimized to prevent unnecessary prolongation in time to surgery. Patients with known aortic stenosis are not associated with increased 30-day or 90-day mortality or all-cause complications. Surgical delays in the yECHO cohort were attributed to preoperative medical assessments including echocardiograms and the management of comorbidities. Therefore, the selective utilization of preoperative echocardiograms is needed, especially strict adherence to ACC/AHA guidelines, and should be reserved to ensure they have a definitive role in guiding the perioperative care of patients with hip fracture.

References

1. Kannus P, Parkkari J, Sievänen H, et al. Epidemiology of hip fractures. *Bone*. 1996;18:57S–63S.
2. Vidán MT, Sánchez E, Gracia Y, et al. Causes and effects of surgical delay in patients with hip fracture: a cohort study. *Ann Intern Med*. 2011;155:226–233.
3. Orosz GM, Hannan EL, Magaziner J, et al. Hip fracture in the older patient: reasons for delay in hospitalization and timing of surgical repair. *J Am Geriatr Soc*. 2002;50:1336–1340.
4. Pincus D, Ravi B, Wasserstein D, et al. Association between wait time and 30-day mortality in adults undergoing hip fracture surgery. *JAMA*. 2017;318:1994–2003.
5. Grimes JP, Gregory PM, Noveck H, et al. The effects of time-to-surgery on mortality and morbidity in patients following hip fracture. *Am J Med*. 2002;112:702–709.
6. Fleisher LA, Fleischmann KE, Auerbach AD, et al. 2014 ACC/AHA guideline on perioperative cardiovascular evaluation and management of patients undergoing noncardiac surgery: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines. *Circulation*. 2014;130:2215–2245.
7. Goldman L, Caldera DL, Nussbaum SR, et al. Multifactorial index of cardiac risk in noncardiac surgical procedures. *N Engl J Med*. 1977;297:845–850.
8. Agarwal S, Rajamanickam A, Bajaj NS, et al. Impact of aortic stenosis on postoperative outcomes after noncardiac surgeries. *Circ Cardiovasc Qual Outcomes*. 2013;6:193–200.
9. Tashiro T, Pislaru SV, Blustin JM, et al. Perioperative risk of major noncardiac surgery in patients with severe aortic stenosis: a reappraisal in contemporary practice. *Eur Heart J*. 2014;35:2372–2381.

10. Bottle A, Aylin P. Mortality associated with delay in operation after hip fracture: observational study. *BMJ*. 2006;332:947–951.
11. Orosz GM, Magaziner J, Hannan EL, et al. Association of timing of surgery for hip fracture and patient outcomes. *JAMA*. 2004;291: 1738–1743.
12. Davis FM, Woolner DF, Frampton C, et al. Prospective, multi-centre trial of mortality following general or spinal anaesthesia for hip fracture surgery in the elderly. *Br J Anaesth*. 1987;59:1080–1088.
13. Bredahl C, Nyholm B, Hindsholm KB, et al. Mortality after hip fracture: results of operation within 12 h of admission. *Injury*. 1992;23:83–86.
14. Bhandari M, Swiontkowski M. Management of acute hip fracture. *N Engl J Med*. 2017;377:2053–2062.
15. Rogers FB, Shackford SR, Keller MS. Early fixation reduces morbidity and mortality in elderly patients with hip fractures from low-impact falls. *J Trauma*. 1995;39:261–265.
16. Zuckerman JD, Skovron ML, Koval KJ, et al. Postoperative complications and mortality associated with operative delay in older patients who have a fracture of the hip. *J Bone Joint Surg Am*. 1995;77:1551–1556.
17. Samarendra P, Mangione MP. Aortic stenosis and perioperative risk with noncardiac surgery. *J Am Coll Cardiol*. 2015;65:295–302.
18. Calleja AM, Dommaraju S, Gaddam R, et al. Cardiac risk in patients aged >75 years with asymptomatic, severe aortic stenosis undergoing noncardiac surgery. *Am J Cardiol*. 2010;105:1159–1163.
19. Wolinsky FD, Fitzgerald JF, Stump TE. The effect of hip fracture on mortality, hospitalization, and functional status: a prospective study. *Am J Public Health*. 1997;87:398–403.
20. Osnabrugge RL, Kappetein AP, Serruys PW. Non-cardiac surgery in patients with severe aortic stenosis: time to revise the guidelines? *Eur Heart J*. 2014;35:2346–2348.
21. Panula J, Pihlajamäki H, Mattila VM, et al. Mortality and cause of death in hip fracture patients aged 65 or older: a population-based study. *BMC Musculoskelet Disord*. 2011;12:105.
22. Andersson C, Jørgensen ME, Martinsson A, et al. Noncardiac surgery in patients with aortic stenosis: a contemporary study on outcomes in a matched sample from the Danish health care system. *Clin Cardiol*. 2014; 37:680–686.
23. Keswani A, Lovy A, Khalid M, et al. The effect of aortic stenosis on elderly hip fracture outcomes: a case control study. *Injury*. 2016;47:413–418.
24. HIP ATTACK Investigators. Accelerated surgery versus standard care in hip fracture (HIP ATTACK): an international, randomised, controlled trial. *Lancet*. 2020;395:698–708.
25. Rudolph TK, Messika-Zeitoun D, Frey N, et al. Impact of selected comorbidities on the presentation and management of aortic stenosis. *Open Heart*. 2020;7:e001271.
26. Rassa A, Zahr F. Hypertension and aortic stenosis: a review. *Curr Hypertens Rev*. 2018;14:6–14.