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ORIGINAL RESEARCH

A Higher Postoperative Barthel Index at Discharge is Associated with a Lower One-Year Mortality After Hip Fracture Surgery for Geriatric Patients: A Retrospective Case–Control Study

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Purpose: To evaluate the relationship between the postoperative Barthel index assessing activities of daily living at discharge and the one-year mortality after hip fracture surgery.

Methods: Patients with hip fracture admitted to Peking University First Hospital from January 2015 to January 2020 were enrolled retrospectively according to the inclusion and exclusion criteria. The Barthel index and other related confounding variables were collected. Logistic regression and Kaplan–Meier survival curves were constructed to explore the relationship between the postoperative Barthel index at discharge and the one-year mortality of geriatric patients after hip fracture surgery.

Results: A total of 444 patients with a mean age of 81.61±6.14 years were included. A significant difference was not observed in the preoperative Barthel index at admission between the deceased group and the surviving group (38.90±15.83 vs 36.96±10.74, *p*=0.446). However, the difference in the postoperative Barthel index at discharge between these two groups was statistically significant (43.08 ±14.40 vs 53.18±13.43, P<0.001). The multivariable logistic regression analysis revealed that the postoperative Barthel index at discharge was an independent risk factor for one-year mortality after adjustment for confounding variables (adjusted OR 0.73, 95% CI 0.55–0.98, p<0.05). The Kaplan–Meier survival curve showed that patients who had a high Barthel index (≥50) at discharge had a significantly lower mortality in the long term than patients with a low Barthel index (<50) at discharge (P< 0.001).

Conclusion: The postoperative Barthel index at discharge was independently associated with the one-year mortality of geriatric patients after hip fracture surgery. A higher postoperative Barthel index at discharge indicated a lower mortality after hip fracture surgery. The Barthel index at discharge has the potential to provide essential prognostic information for early risk stratification and directing future care.

Keywords: Hip fracture, Barthel index, one-year mortality, geriatrics, at discharge

Introduction

Hip fracture is a devastating public health problem with a high epidemiology worldwide in geriatrics.[1,2] High disability rates, mortality and social cost after hip fracture impose substantial pressure on patients and their care providers. The mortality one year after hip fracture is estimated to range from 2.4% to 34.8%.[2–4] Many risk factors and models are proposed to stratify the mortality risk after hip fracture surgery. Demographic characteristics, including age, sex and BMI (body mass index), comorbidities, complications and special laboratory test results, such as serum albumin and haemoglobin levels, were identified as risk factors.[2,5] The delay of surgery and other factors associated with surgery have been shown in other study.[5] Several predictive models were

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constructed based on these risk factors.[6,7] However, the accuracy of the models stratifying the mortality risk after hip fracture surgery was not satisfactory,[6,7] and the levels of activities of daily living after surgery were rarely explored as potential risk factors.

Hip fracture impairs activity levels, even after surgery. Approximately 30% to 80% of patients lose functional independence after hip fracture.[1,8] The Barthel index is one of the most widely used tools assessing functional independence and activity of daily living. Several studies confirmed that the Barthel index affected mortality in geriatric patients,[9,10] or patients with heart diseases[11–13] or pneumonia.[14] Other studies found that the Barthel index seemed useful for the assessment of activities of daily living and functional recovery in patients with hip fracture.[15–17] However, few studies have explored the relationship between the Barthel index and one-year mortality after hip fracture surgery in geriatric patients.

This study aimed to explore whether the postoperative Barthel index at discharge was independently associated with the one-year mortality after hip fracture surgery in geriatric patients.

Methods and Patients

Study Population

This study was approved by the Peking University First Hospital Ethics Committee. The patients with hip fracture who were admitted to Peking University First Hospital from January 2015 to January 2020 were enrolled retrospectively. The inclusion criteria were as follows: 1) patients were diagnosed with a femoral neck fracture or intertrochanteric fracture; 2) the age at admission was no less than 70 years; and 3) patients were treated with surgery, including internal fixation (such as SHS or DHS, cephalo-medullary nail, multiple screw and so on) or hip arthroplasty. The exclusion criteria were as follows: 1) hip fracture identified as a pathological fracture; 2) death before discharge due to extremely severe complications and thus the Barthel index could not be acquired at discharge; and 3) loss to follow-up.

Variables and Study Endpoints

Variables extracted were divided into several groups, including demographic characteristics, comorbidities, preoperative laboratory test results and parameters related to surgery. Demographic characteristics were age, sex and BMI. Comorbidities included heart disease, neurovascular disease, hypertension, diabetes mellitus and others. Health status was evaluated by calculating the age-adjusted Charlson Comorbidities Index (aCCI) and American Society of Anaesthesiologists (ASA) score.[18] The aCCI was calculated using the original Charlson Comorbidities Index with an additional 4 points added for patients older than 70 years.[19,20] Preoperative laboratory test results included the serum albumin, sodium and haemoglobin levels at admission. Parameters related to surgery included the fracture type, days the operation was delayed, anaesthesia type, transfusion, surgery type, postoperative complications and the total length of stay (LOS) in the hospital. Postoperative complications included atrial fibrillation, heart failure, delirium, myelosuppression, gastrointestinal haemorrhage, acute cerebral vascular disease, pulmonary infection, hypotension, urinary tract infection, acute kidney failure, acute respiratory failure, acute cardiovascular diseases, deep vein thrombosis, pulmonary embolism, and shock, among others.

The patients were followed by telephone for at least one year after surgery. The primary endpoint was one-year mortality. The secondary endpoint was the long-term survival rate for up to 6 years.

Barthel Index

The activities of daily living (ADL) were evaluated with the Barthel index, which is one of the most widely used tools assessing functional independence.[21] The Barthel index comprises 10 items: feeding, bathing, grooming, dressing, bowel control, bladder control, toilet use, transfers (bed to chair and back), mobility on level surfaces, and stairs. Four response categories are assigned to each item, and the total score ranges from 0 to 100 points with a fixed interval of 5 points. The higher the score, the greater the activities of daily living. The Barthel index was acquired by nurses when the patients were admitted to the hospital and discharged from the hospital. Thus, two Barthel index scores, namely, the preoperative Barthel index at admission and the postoperative Barthel index at discharge, were acquired for each patient.

Statistical Analysis

Categorical variables are presented as the numbers of patients (n, %) and were analysed using Pearson's chi-square test. Continuous variables are presented as the means ± standard deviation or medians with 95% confidence intervals (CIs) when needed and were analysed using one-way ANOVA (analysis of variance) or the Kruskal–Wallis test.

The association between the early postoperative Barthel index at discharge and one-year mortality after surgery was analysed using univariable and multivariable logistic regression models. Univariable logistic regression was conducted to identify potential risk factors for one-year mortality after surgery based on a threshold p value below 0.05. Multivariable logistic regression was conducted to identify independent risk factors for one-year mortality after surgery, based on a threshold p value below 0.05. The Barthel index was divided by 10 for its fixed interval of 5 before being analysed using a logistic regression models. Models were adjusted for the following potential confounding variables: age, sex, BMI, aCCI, ASA score, albumin level, sodium level, haemoglobin level, surgery types and complications. The odds ratio (OR) was acquired and is presented with 95% CIs and p values. The Kaplan–Meier survival curve was constructed according to the level of the postoperative Barthel index at discharge and analysed using the Log rank test.

All data were analysed with SPSS Statistics version 25 (SPSS, Inc., Chicago, IL, USA), and a p value less than 0.05 was considered a significant difference.

Results

In total, 444 patients with a mean age of 81.61±6.14 years were included in this study, and 322 (72.52%) were females. A screening diagram of the enrolled patients is shown in Figure 1. A total of 266 (59.90%) patients were diagnosed with a femoral neck fracture. A total of 238 (53.60%) patients were treated with total or hemi-hip arthroplasty, and the remainder were treated with internal fixation with screws, plates or intramedullary nails. Forty-one (8.45%) patients were lost to follow-up. The mean follow-up time after discharge was 35.56±19.80 months, and the overall mortality one year after hip fracture surgery was 9.7%. According to the survival status one year after surgery, the patients were divided into the deceased group and the surviving group. Their characteristics, including demographic characteristics, comorbidities, preoperative laboratory test results and parameters related to surgery, are listed in Table 1.

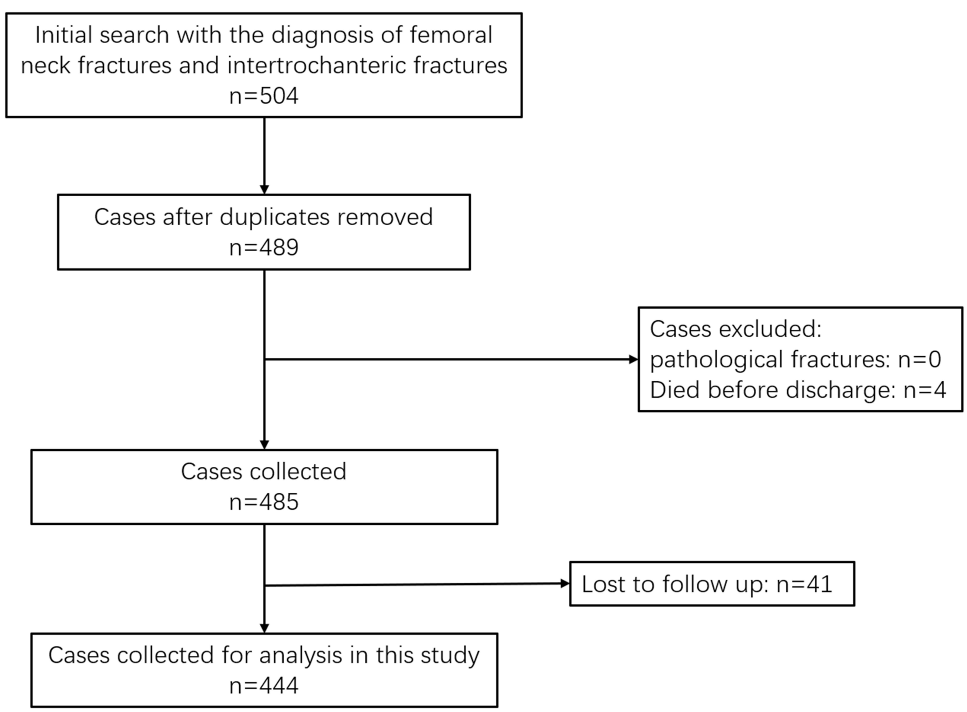

Figure 1 Flow chart of patient inclusion.

Table 1 Demographic and Clinic Characteristics of the Patients Included in This Study

Variables	Dead Group (One Year Post Surgery)	Survival Group (One Year Post Surgery)	*p* value
Number	43	401	
Demographic characteristics			
Age, y, mean±SD	83.02±5.63	81.46±6.18	0.113
Gender (female, n%)	26 (60.47%)	296 (73.82%)	0.062
BMI, kg/m^2, mean±SD	20.50±3.79	22.78±4.17	0.001*
Comorbidities			
aCCI, mean±SD	6.21±2.12	5.10±1.25	0.002*
ASA, mean±SD	2.77±0.65	2.58±0.58	0.049*
Heart disease (n%)	13 (30.23%)	149 (37.16%)	0.370
Neurovascular disease (n%)	9 (20.93%)	108 (26.93%)	0.396
Hypertension (n%)	23 (53.49%)	258 (64.34%)	0.161
Diabetes Mellitus (n%)	12 (27.90%)	103 (25.94%)	0.781
Preoperative laboratory test results			
Alb, g/L, mean±SD	34.55±4.73	37.51±3.54	0.000*
Na, mmol/L, mean±SD	136.58±4.78	138.00±3.63	0.065
Hb, g/dL, mean±SD	10.78±1.98	12.11±1.63	0.000*
Parameters related to surgery			
Fracture type (FNF, n%)	21 (48.84%)	245 (61.10%)	0.119
Operation delay, day, mean±SD	3.49±2.89	2.84±2.34	0.161
Anesthesia type (CSEA, n%)	31 (72.10%)	296 (74.00%)	0.787
Transfusion (n%)	26 (60.47%)	159 (39.65%)	0.009*
Surgery (THA or HHA, n%)	20 (46.51%)	218 (54.36%)	0.326
Complications (n%)	17 (39.53%)	61 (15.21%)	0.000*
Length of stay (day, mean ± standard deviation)	14.77±6.98	12.85±8.82	0.169

Note:*P < 0.05 with significant difference.
Abbreviations: SD, Standard Deviation; BMI, Body Mass Index; aCCI, age-adjusted Charlson Comorbidities Index; ASA, American Society of Anesthesiologists; FNF, Femoral neck fracture; CSEA, Combined spinal-epidural anesthesia; THA, Total hip arthroplasty; HHA, Hemi hip arthroplasty.

A significant difference was not observed in the preoperative Barthel index at admission between the deceased group and the surviving group (38.90±15.83 vs 36.96±10.74, p = 0.446). However, the difference in the postoperative Barthel index at discharge between these two groups was significant (43.08±14.40 vs 53.18±13.43, P< 0.001), as shown in Figure 2. The mean duration from

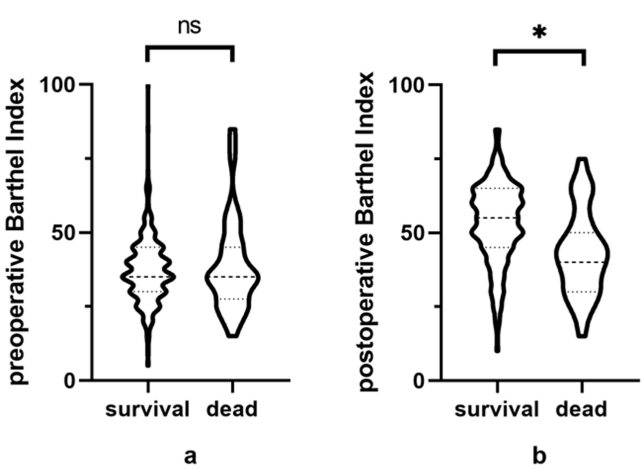

Figure 2 The comparison of preoperative and postoperative Barthel index between patients who survived in one year and died in one year after hip fracture surgery. (**a**) No significant difference was found in preoperative Barthel index at admission between patients who survived in one year and died in one year after Hip fracture surgery. (**b**) Significant difference was found in postoperative Barthel index at discharge between patients who survived in one year and died in one year after hip fracture surgery. *Significant difference (P< 0.001).
Abbreviation: ns, no significant difference.

Table 2 Univariate and Multivariate Logistic Regression of Variables for One-Year Mortality After Hip Fracture Surgery in Geriatrics

Variables	Univariate Analysis		Multivariate Analysis	
	P	**OR (95% CI)**	***P***	**Adjusted OR (95% CI)**
Age	0.113	NA	0.845	NA
Gender	0.062	NA	0.007*	0.33(0.15–0.74)
BMI	0.002	0.88 (0.80–0.95)	0.139	NA
aCCI	0.000	1.52(1.27–1.83)	0.008*	1.38(1.09–1.74)
ASA	0.051	1.68(1.00–2.82)	0.888	NA
Albumin	0.000	0.82(0.75–0.89)	0.283	NA
Na	0.020	0.92(0.85–0.99)	0.495	NA
Hb	0.000	0.64(0.54–0.78)	0.000*	0.57(0.45–0.73)
Transfusion	0.010	2.33(1.22–4.43)	0.470	NA
Complications	0.000	3.64(1.87–7.12)	0.129	NA
Postoperative Barthel Index	0.000	0.61(0.48–0.77)	0.038*	0.73(0.55–0.98)

Note: *P < 0.05 with significant difference.
Abbreviations: BMI, Body Mass Index; aCCI, age-adjusted Charlson Comorbidities Index; ASA, American Society of Anesthesiologists; NA, not applicable; OR, Odds ratio.

surgery to discharge was 10.09±8.29 days. No significant difference in the duration from surgery to discharge was observed between these two groups (11.27±6.44 vs 9.96±8.46, p = 0.328).

The multivariable logistic regression analysis revealed that the postoperative Barthel index at discharge was an independent risk factor for one-year mortality after adjustment for confounding variables (adjusted OR 0.73, 95% CI 0.55–0.98, p<0.05), as shown in Table 2. A 10-point increase in the postoperative Barthel index at discharge was associated with a decrease in the one-year mortality by a factor of 0.73.

Based on the midpoint of the postoperative Barthel index at discharge, the patients were divided into a high Barthel index group (Barthel index ≥50) and a low Barthel index group (Barthel index <50). The Kaplan–Meier survival curve showed that patients with a high Barthel index at discharge had a significantly lower mortality risk after assessing long-term survival for durations of up to 6 years than patients with a low Barthel index at discharge (P< 0.001), as shown in Figure 3. Median survival rates of the high Barthel index group is 0.962 ± 0.011; Median survival rates of the low Barthel index group is 0.835 ± 0.032.

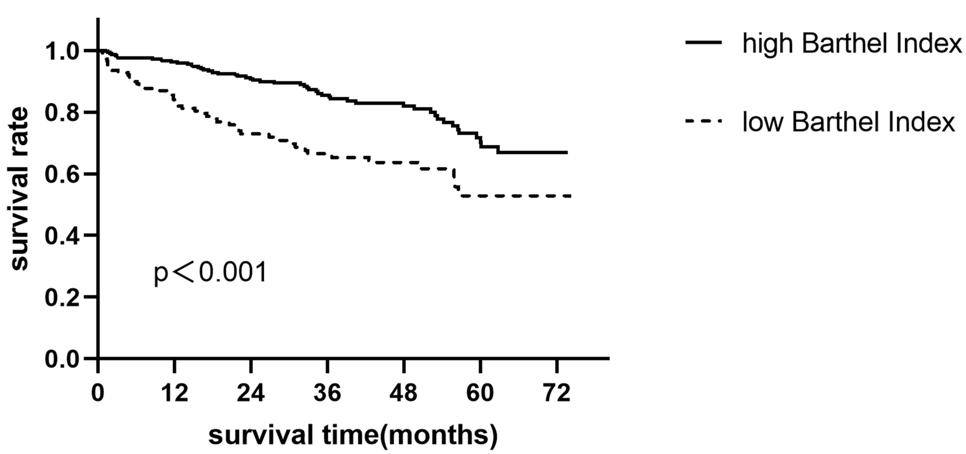

Figure 3 The Kaplan-Meier survival curve showed that patients with high Barthel index (≥50) at discharge had significantly lower mortality in long-term survival duration up to 6 years compared to patients with low Barthel index (<50) at discharge (P<0.001).

Discussion

Disability and mortality after hip fracture remain high in geriatric patients. After adjusting for available confounding variables, the postoperative Barthel index at discharge was an independent risk factor for one-year mortality after hip fracture surgery. An increase in the postoperative Barthel index at discharge indicated a decrease in the one-year mortality. Furthermore, patients with a high postoperative Barthel index (≥50) at discharge had a significantly lower mortality in an assessment of their long-term survival for up to 6 years. Thus, the postoperative Barthel index at discharge was a significant factor stratifying the mortality after hip fracture surgery in geriatric patients.

The Barthel index, which can be easily determined by nurses and interpreted in clinical practice, is a simple and highly reliable tool to evaluate activities of daily living.[22,23] The Barthel index is a tool to evaluate activities of daily living after hip fracture surgery. With common knowledge of drop in mobility post surgery, someone would expect drop in postoperative Barthels index compared to preoperative Barthels index. But the main purpose of surgery is to maximize the recovery of function, so compared with the preoperative, the patient must have a higher Barthel index at discharge. This is how the Barthel index changes before and after surgery compared to other operations, such as surgical treatment of tumors. Some studies have explored the validity and responsiveness of the Barthel index to assess functional recovery in hip fracture patients. Unnanuntana et al[24] confirmed that the Barthel index had good validity in assessing functional recovery in patients who underwent hemiarthroplasty after femoral neck fracture due to its mild to moderate association with the EuroQol visual analogue scale (EQ-VAS) and moderate to strong association with the Morton Mobility Index (DEMMI) and performance-based tests. Inui et al[25] found that the early postoperative Barthel index after trochanteric fractures was associated with long-term walking ability. Other studies also used the Barthel index to evaluate functional recovery after hip fracture surgery.[16,17] Thus, the use of the Barthel index to evaluate functional recovery after hip fracture surgery in this study was reliable and reasonable. However, the relationship between the Barthel index and mortality of geriatric patients after hip fracture surgery has rarely been investigated.

The association between the Barthel index and mortality has also been explored in patients with other diseases. According to Li et al, the Barthel index at admission is useful for early risk stratification, and the Barthel index is an independent risk factor for all-cause mortality over a median follow-up duration of 10.63 months.[11] In a Danish nationwide study,[9] Ryg et al found that the Barthel index at admission was independently and strongly associated with mortality within a long follow-up time of 11 years for patients aged ≥65 years. Bahrmann et al reported that both the CCI and Barthel index independently predict mortality in unselected geriatric patients.[26] Other studies also documented similar results for patients with other diseases, and a higher Barthel index indicated a lower mortality.[10,12–14] These results were consistent with our finding that a higher Barthel index at discharge indicated a lower mortality after hip fracture surgery in geriatric patients. A higher Barthel index indicates higher functional independence and a better health status. Thus, patients with a higher Barthel index are able to move easily and have a better quality of life with fewer complications, and their survival duration may be prolonged.

The postoperative Barthel index in our study was acquired at discharge within a mean time point of 10.09 days after surgery, although some other studies acquired the Barthel index at admission[9,11,12] or at discharge.[16,17] The Barthel index recorded at admission in our study was not significantly different between patients who survived or died at one year postoperatively. Actually, disability in geriatric patients is mainly affected by pre-existing illnesses and injuries leading to hospitalization.[27] As shown by Covinsky et al[28] most patients recover to their original functional status before discharge. Different diseases, especially injuries, greatly affect activities of daily living. Hip fracture is a severe injury to geriatric patients and exerts a tremendous effect on their activities of daily living. Thus, the Barthel index at admission must decrease substantially after hip fracture, and the difference between groups was unable to be discovered. After hip fracture surgery, the patients recovered from the acute injury but were still affected by the hip fracture and surgery to some extent. The Barthel index at discharge might accurately reflect the effects of their pre-existing illnesses, new hip fracture, and corresponding surgery. Thus, the postoperative Barthel index at discharge might provide a better prediction of mortality after hip fracture surgery.

The postoperative Barthel index at discharge was divided into two groups based on the cut-off value of 50, and a high Barthel index at discharge was related to a low mortality after hip fracture surgery. This cut-off value for the Barthel index has been used in previously published studies.[10,29] In these studies, a Barthel index less than 50 was categorized as severe dependence, and severely dependent patients had a worse prognosis, consistent with our findings.

Several limitations existed in this study. First, this study employed a retrospective design with a limited number of patients. Although much effort was made, selection and information bias could not be avoided. Although our sample size is small, our study is very meaningful. We found a relationship between Barthel index and 1-year mortality after hip fracture, which would raise clinicians' attention to Barthel index and encourage them to develop effective postoperative treatment plans to improve discharge Barthel index. In our center, the one-year mortality after hip fracture was low, we will further increase the sample size and conduct multi-center joint research in future. Second, the postoperative Barthel index was acquired at discharge, but the time of discharge after surgery differed for every patient. Researchers have not explored whether the duration from surgery to discharge would change the Barthel index. In the present study, the duration from surgery to discharge was limited to 10.09±8.29 days, and no significant difference was observed between those two groups. Third, the postoperative Barthel index at discharge was divided by the cut-off value of 50. However, different cut-off values of the Barthel index were used in different studies and for patients with different diseases. Although we have already shown that the Barthel index, a consecutive variable, was significantly associated with the one-year mortality after hip fracture surgery, the best cut-off value of the Barthel index after hip fracture surgery in geriatric patients should be explored in future studies.

Conclusions

Our study showed that the Barthel index at discharge was independently associated with one-year mortality after hip fracture in geriatric patients and that the higher the Barthel index at discharge, the lower the mortality after hip fracture surgery. The Barthel index at discharge has the potential to provide essential prognostic information for early risk stratification and directing future care.

Abbreviations

BMI, body mass index; aCCI, age-adjusted Charlson Comorbidities Index; ASA, American Society of Anaesthesiologists; LOS, length of stay; ADL, activity of daily living; SD, standard deviation; CI, confidence interval; ANOVA, analysis of variance; OR, odds ratio; EQ-VAS, EuroQol visual analogue scale; DEMMI, de Morton Mobility Index.

Ethical Approval and Consent for Publication

This study was approved by the Institutional Ethics Committee of Peking University First Hospital (No. 2021-432), and complied with the Declaration of Helsinki. The informed consent was waived because it was a retrospective study. All the data collected was confidential.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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