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Original Research

Aspartate Aminotransferase–to–Platelet Ratio Index Suggestive of Liver Dysfunction Predicts Early Complications After Open Reduction Internal Fixation of Distal Radius Fractures

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Purpose: Aspartate aminotransferase–to–platelet ratio index (APRI) is a cost-effective and noninvasive measure of liver function, an alternative to the gold standard liver biopsy, which is resource-intensive and invasive. The purpose of this study was to investigate the association between preoperative APRI and 30-day postoperative complications after isolated open reduction internal fixation (ORIF) of distal radius fractures (DRFs).

Methods: The American College of Surgeons National Surgical Quality Improvement Program database was queried for all patients who underwent isolated ORIF of DRFs between 2015 and 2021. The study population was divided into two groups on the basis of preoperative APRI: normal/reference (APRI, <0.5) and liver dysfunction (APRI, ≥0.5). Information on patient demographics, comorbidities, and 30-day postoperative complications after isolated ORIF of DRFs was collected. Multivariate logistic regression analysis was performed to investigate the relationship between preoperative APRI and postoperative complications.

Results: Compared to patients with normal APRI, patients with preoperative APRI associated with liver dysfunction were significant for male sex ($P < .001$), younger age ($P < .001$), American Society of Anesthesiologists classification grade ≥3 ($P < .001$), being smokers ($P < .001$), and having comorbid diabetes ($P = .002$) and bleeding disorders ($P < .001$). Preoperative APRI associated with liver dysfunction was independently associated with a greater likelihood of any complications (odds ratio [OR], 1.49; 95% confidence interval [CI], 1.19–1.87; $P < .001$), nonhome discharge (OR, 1.62; 95% CI, 1.15–2.27; $P = .005$), and a length of stay of >2 days (OR, 1.70; 95% CI, 1.32–2.20; $P < .001$).

Conclusions: Aspartate aminotransferase–to–platelet ratio index values associated with liver dysfunction were associated with an increased rate of early postoperative complications after DRF ORIF.

Clinical relevance: This study suggests APRI's utility as a cost-effective, noninvasive measure of liver function that physicians can use before surgery to better identify surgical candidates with DRFs and suspicion of liver dysfunction.

Type of study/level of evidence: Prognostic III.

In the United States, distal radius fractures (DRFs) are the most common long bone fractures and the most common upper extremity fractures in most age groups, accounting for one-sixth of emergency department visits and 26% to 46% of all skeletal fractures in primary care.[1,2] The incidence of DRF is increasing worldwide, with more than $210 million spent on DRF treatment in the elderly patient population.[3] Given this increase, it is important to investigate and understand preoperative risk factors that can impact postoperative outcomes in patients undergoing surgical treatment for DRFs.

Previous studies have identified multiple comorbidities that were associated with increased rates of postoperative complications after open reduction internal fixation (ORIF) of DRFs.[4,5] Chronic obstructive pulmonary disease was an independent risk

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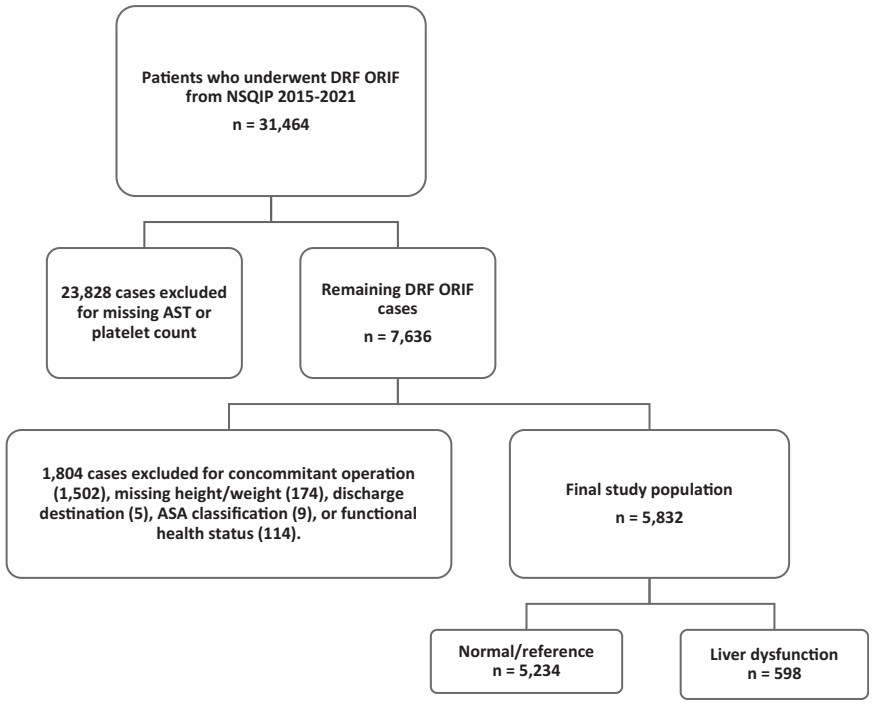

Figure 1. Case selection schematic.

factor for postoperative complications including transfusion, extended length of hospital stay, and readmission.[4] Diabetes, osteoporosis, congestive heart failure, obesity, tobacco use, and hypertension have also been associated with increased risks of complications, with hypertension having the strongest correlation with poorer outcomes.[5] However, there is limited literature regarding the relationship between liver disease and postoperative outcomes after ORIF of DRFs.

Cirrhosis and liver disease have been studied as comorbidities that may affect postoperative outcomes in other orthopedic procedures.[6–8] Cirrhotic patients exhibit higher rates of postoperative complications, such as greater risk of readmission, mortality during or after hospitalization, and transfer to an intensive care unit.[9] Furthermore, patients with end-stage liver disease are three times more likely to have any complication after total joint replacement.[10] These results suggest a need to explore liver disease as a predictor of postoperative adverse outcomes in patients undergoing DRF ORIF. The preoperative aspartate aminotransferase (AST)—to—preoperative platelet ratio index (APRI) can be readily calculated from preoperative laboratory values and is used to noninvasively estimate the degree of liver dysfunction. Typically, liver function tests prior to nonhepatic surgery are recommended in patients with either diagnosed liver disease, clinical suspicion of liver dysfunction, or notable risk factors based on history and physical examination rather than all patients.[11] Previous studies have shown that APRI can distinguish between different levels of fibrosis with good sensitivity and specificity.[12,13]

This study aims to investigate the association between APRI and postoperative complications in patients with DRF who underwent isolated ORIF. We hypothesized that there are increased postoperative complications in patients with increasing severity of liver disease compared to patients with normal liver function APRI predictive of liver dysfunction.

Methods

We queried the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database for all patients who underwent isolated ORIF of DRFs between 2015 and 2021. This study was exempted from approval by the Institutional Review Board of Stony Brook University because the NSQIP database is fully deidentified. Data in the NSQIP database are obtained from more than 600 hospitals in the United States and are collected by trained surgical clinical reviewers. These data are periodically audited to maintain high fidelity.

Current Procedural Terminology codes 25607, 25608, and 25609 were used to identify 31,464 patients who underwent ORIF of DRFs, including extra-articular, intra-articular, and intra-articular comminuted fractures, between 2015 and 2021. The exclusion criteria inherent to the NSQIP database automatically excludes all cases for patients younger than 18 years of age or cases with primary admission related to trauma. Twenty-three thousand eight hundred twenty-eight patients with missing preoperative AST or platelet data were excluded, leaving 7,636 patients. Cases were also excluded if they underwent a concurrent operation (1,502) or had any of the following missing information: height/weight (174 excluded), discharge destination (5 excluded), American Society of Anesthesiologists (ASA) classification (9 excluded), and functional health status (114 excluded). For the remaining study population, we used 40 units/liter as the upper limit of normal AST and calculated the preoperative APRI using the following formula:[14]

$$APRI = \frac{AST \times 100}{Upper\ limit\ of\ normal\ AST \times Platelet\ count\ (in\ thousands)}$$

The remaining study population (Fig.) was then indexed into two cohorts on the basis of their preoperative APRI: normal/reference (APRI, <0.5) and liver dysfunction (APRI, ≥0.5). An APRI cutoff value of 0.5 was chosen because it is a validated threshold with at least 74% sensitivity and 49% specificity for at least some degree of liver damage, with increasing sensitivity and specificity for greater degrees of liver dysfunction.[14–16] Of the 5,832 total patients in the study, 5,234 belonged to the normal group and 598 belonged to the liver dysfunction group.

Table 1
Demographics and Comorbidities of Patients with Preoperative Normal APRI and Liver Dysfunction*

Patient Demographic/Cormorbidity Factor	Normal (≤0.5)	Liver Dysfunction (≥0.5)	
	Number (%)	Number (%)	*P* Value
Overall	5,234 (100.0)	598 (100.0)	
Sex			**<.001**
Female	4,143 (79.2)	364 (60.9)	
Male	1,091 (20.8)	234 (39.1)	
Age (y)			**<.001**
18–39	507 (9.7)	71 (11.9)	
40–64	2,260 (43.2)	310 (51.8)	
65–74	1,444 (27.6)	121 (20.2)	
≥75	1,023 (19.50)	96 (16.1)	
BMI (kg/m^2)			.406
<18.5	126 (2.4)	21 (3.5)	
18.5–29.9	3,154 (60.3)	337 (56.4)	
30–34.9	1,084 (20.7)	132 (22.1)	
35–39.9	492 (9.4)	63 (10.5)	
≥40	378 (7.2)	45 (7.5)	
Functional status prior to surgery			.183
Dependent	166 (3.2)	13 (2.2)	
Independent	5,068 (96.8)	585 (97.8)	
ASA classification grade			**<.001**
≤2	2,980 (56.9)	272 (45.5)	
≥3	2,254 (43.1)	326 (54.5)	
Smoker			**<.001**
No	4,282 (81.8)	446 (74.6)	
Yes	952 (18.2)	152 (25.4)	
Steroid use			.600
No	5,018 (95.9)	576 (96.3)	
Yes	216 (4.1)	22 (3.7)	
Comorbidities			
CHF	52 (1.0)	10 (1.7)	.130
Diabetes	690 (13.2)	106 (17.7)	**.002**
Hypertension	2,435 (46.5)	286 (47.8)	.545
COPD	327 (6.2)	41 (6.9)	.562
Bleeding disorder	170 (3.2)	38 (6.4)	**<.001**

BMI, body mass index; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease.
* Bold *P* values indicate statistical significance with $P < .05$.

Variables collected in this study included patient demographics, comorbidities, and 30-day postoperative complication data. Patient demographics included sex, body mass index, age, smoking status, functional status, ASA classification, and preoperative steroid use. Preoperative comorbidities included congestive heart failure, diabetes, hypertension, severe chronic obstructive pulmonary disorder, and bleeding disorders. Complications that occurred within 30 days after surgery were included in the analysis. These complications included sepsis, septic shock, pneumonia, unplanned reintubation, urinary tract infection, cardiac arrest or myocardial infarction, stroke, blood transfusions, deep vein thrombosis, pulmonary embolism, being on ventilator for >48 hours, surgical space infection (SSI) or wound dehiscence, acute renal failure, *Clostridioides difficile* infection, nonhome discharge, readmission, unplanned reoperation, a length of stay of >2 days, and mortality. Any complication was defined as any patient who experienced any of the aforementioned complications. Major complications included the following: cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, deep vein thrombosis, stroke, unplanned intubation, pulmonary embolism, failure to wean off a ventilator within 48 hours, sepsis, septic shock, deep incisional SSI, organ/space SSI, readmission, reoperation, and mortality. Minor complications included the following: pneumonia, urinary tract infection, blood transfusions within 72 hours of surgery, wound dehiscence, and superficial incisional SSI.

Patient demographics, comorbidities, and complications were compared between the normal/reference and liver dysfunction cohorts using binomial and multinomial logistic regression. Next, multivariate logistic regression, adjusted for all associated patient demographics and comorbidities, including sex, age, ASA classification, smoking status, diabetes, and bleeding disorders, was used to identify independent associations between preoperative APRI and the significant postoperative complications on bivariate analysis, including any complication, nonhome discharge, and a length of stay of >2 days. Odds ratios (ORs) were reported with 95% confidence intervals (CI). The level of statistical significance was set at $P < .05$.

Results

Of the 5,832 total patients in the study, 5,234 belonged to the normal group and 598 belonged to the liver dysfunction group. Compared to the normal APRI group, the liver dysfunction group was statistically significant for male sex ($P < .001$), younger age groups (18–39 years and 40–64 years) ($P < .001$), ASA classification grade ≥ 3 ($P < .001$), smokers ($P < .001$), and comorbid diabetes ($P = .002$) and bleeding disorders ($P < .001$) (Table 1).

Compared to the normal APRI group, the liver dysfunction group was found to have a statistically significant association with the following 30-day postoperative complications: any complication ($P < .001$), nonhome discharge ($P = .003$), and a length of stay of >2 days ($P < .001$) (Table 2).

After controlling for all patient demographic and comorbidity factors, an adjusted multivariate regression analysis was performed (Table 3). Compared with the normal APRI group, the liver dysfunction group was independently associated with a greater likelihood of any complication (OR, 1.49; 95% CI, 1.19–1.87; $P < .001$), nonhome discharge (OR, 1.62; 95% CI, 1.15–2.27; $P = .005$), and a length of stay of >2 days (OR, 1.70; 95% CI, 1.32–2.20; $P < .001$).

Discussion

In this study, we used a large national database and found that preoperative APRI values predictive of liver dysfunction were a risk factor for 30-day postoperative complications in patients who underwent isolated ORIF of DRFs. Specifically, our study found that preoperative APRI values ≥0.5 are an independent predictor of any complication, nonhome discharge, and a length of stay of >2 days. Our data suggest that the use of APRI as an indicator of liver disease may be helpful in risk stratification for patients with isolated DRF undergoing ORIF.

Adverse effects of liver disease after total joint procedures, specifically total hip arthroplasty and total knee arthroplasty, are well documented. Patients with cirrhosis are found to have a higher risk for infection and increased bleeding, as well as increased rates of readmission, mortality, and longer hospital stays.[6,7] One study compared the impacts of different comorbidities, including congestive heart failure and chronic kidney disease, on postoperative complications after total hip arthroplasty and total knee arthroplasty and found that cirrhosis had the greatest OR of patients developing surgical complications.[8]

Our analysis found that the fibrosis group had higher rates of male sex, younger age groups (18–34 and 40–64 years), ASA classification grade ≥3, smokers, diabetes, and bleeding disorders. The significant associations of liver dysfunction ($P < .001$) with men support existing studies reporting that show cirrhotic patients are more likely to be male.[9,17] The association with fibrosis and ASA classification grade ≥3 aligns with trends in existing literature showing that cirrhotic patients have a greater number of comorbidities compared to noncirrhotic patients.[9]

Currently, there exists no literature comparing the demographics of DRF ORIF patients with and without liver disease.

Table 2
Bivariate Analysis of 30-Day Postoperative Complications in Patients with Normal Preoperative APRI and Liver Dysfunction*

Complication	Normal (≤0.5)	Liver Dysfunction (≥0.5)	
	Number (%)	Number (%)	*P* Value
Any complication	698 (13.3)	119 (19.9)	**<.001**
Sepsis	5 (0.1)	1 (0.2)	.609
Septic shock	0 (0.0)	4 (0.7)	.999
Pneumonia	13 (0.2)	2 (0.3)	.695
Unplanned reintubation	3 (0.1)	2 (0.3)	.053
UTI	38 (0.7)	2 (0.3)	.284
Cardiac arrest or MI	12 (0.2)	1 (0.2)	.761
Stroke	3 (0.1)	0 (0.0)	.999
Blood transfusions	7 (0.1)	3 (0.5)	.055
DVT	7 (0.1)	0 (0.0)	.999
PE	9 (0.2)	0 (0.0)	.999
On ventilator for >48 h	3 (0.1)	1 (0.2)	.354
SSI or wound dehiscence	23 (0.4)	2 (0.3)	.711
Acute renal failure	0 (0.0)	1 (0.2)	1.000
Clostridioides difficile infection	2 (0.0)	1 (0.2)	.228
Nonhome discharge	268 (5.1)	48 (8.0)	**.003**
Readmission	128 (2.4)	22 (3.7)	.073
Unplanned reoperation	52 (1.0)	6 (1.0)	.982
Length of stay >2 d	463 (8.8)	90 (15.1)	**<.001**
Mortality	9 (0.2)	3 (0.5)	.108

DVT, deep vein thrombosis; MI, myocardial infarction; PE, pulmonary embolism; UTI, urinary tract infection.
* Bold *P* values indicate statistical significance with $P < .05$.

Table 3
Multivariate Analysis of 30-Day Postoperative Complications in Patients with Normal Preoperative APRI and Liver Dysfunction*

Complication	OR, *P* Value (95% CI)
Any complication	1.49, **<.001** (1.19–1.87)
Nonhome discharge	1.62, **.005** (1.15–2.27)
Length of stay >2 d	1.70, **<.001** (1.32–2.20)

* Bold *P* values indicate statistical significance with $P < .05$.

However, there are data that exist on the overall demographics of patients with DRFs. Two studies found a bimodal distribution of DRF incidence, with peaks at ages younger than 18 years and older than 50 years. There is a higher proportion of boys compared to girls with DRFs in the pediatric population, which then reverses to a greater percentage of women compared to men in the older age group.[1,18] Although the literature shows a greater proportion of women compared to men having DRFs after the age of 50 years, this study investigates the demographic of patients with liver disease who are more likely to be men. This explains why the abnormal APRI groups are associated with a greater proportion of younger men rather than older women.

After controlling for all demographic variables, our study showed that APRI predictive of liver dysfunction was significantly associated with postoperative outcomes. These findings demonstrate a trend of increasing complications as the APRI increases, which supports preexisting literature in both general and orthopedic surgeries. One study investigating APRI as a predictor of outcomes after surgical repair of tibia fracture found that APRI values predictive of cirrhosis had increased rates of readmission, reoperation, and infections after surgical repair of tibia fracture.[17] Similarly, another study investigating APRI as a predictor of complications after total joint arthroplasties found that patients with APRI scores of two or more had significantly higher rates of total complications after total joint arthroplasty.[19] We found, specifically, that APRI predictive of liver dysfunction was an independent predictor of nonhome discharge and a hospital length of stay of >2 days. These findings concur with preexisting research showing that patients with liver cirrhosis who undergo total hip arthroplasty and total knee arthroplasty had an increased risk of early postoperative complications, including prolonged length of stay and discharge to nursing facilities.[20]

The gold standard for determining liver health is a liver biopsy, which is invasive and takes substantial time.[21] Noninvasive methods, such as APRI, can readily estimate liver function by using values collected in routine preoperative laboratory testing. The findings from this study are based on APRI scoring, but there is still mixed evidence on using APRI as an accurate assessment of liver function. Some studies show that this measurement predicts liver cirrhosis and fibrosis with a high degree of accuracy, performing similarly to liver biopsy.[22] However, there exist others that have found it to have limited accuracy in particular situations, such as in extensive fibrosis.[12,23,24]

There are several limitations to our study that are associated with the available information in the NSQIP database. One limitation is that postoperative surgical outcomes are followed only within a 30-day period, so we cannot account for long-term complications after 30 days that could eventually impact patient recovery. Since DRF ORIF patients who receive preoperative liver function tests are those with diagnosed liver disease, clinical suspicion of liver dysfunction, or notable risk factors, the study population consists of both patients with and without previously diagnosed liver disease.[2] However, the database contains limited information related to patients' medical history. Therefore, we were unable to separate patients with and without previous liver disease-related diagnoses to investigate APRI as a screening tool versus as a confirmatory test or investigate differences in complication rates based on open versus closed fracture patterns. Moreover, the NSQIP database does not include nonsurgical patients, limiting our ability to compare surgical versus nonsurgical outcomes in patients with DRFs having an abnormal APRI. Additionally, the NSQIP database does not include cases with primary admission related to trauma. Because DRF is common in patients suffering from polytrauma, cases excluded from the NSQIP database, our study population is limited to patients who likely suffered DRFs secondary to low-energy fractures or isolated trauma. Finally, this study does not consider factors that may change preoperative platelet count, such as platelet transfusion. Therefore, our findings do not account for the possibility of notable postoperative changes in patients' medication or anticoagulant regimes that could impact surgical outcomes.

This study investigates the role of APRI as a noninvasive estimate of liver function and its relationship to postoperative outcomes after ORIF in patients with DRFs. Noninvasive methods, such as APRI, can readily estimate liver function using values collected during preoperative laboratory testing. This study suggests APRI's utility as a cost-effective, noninvasive tool that physicians can use before surgery to better identify surgical candidates with DRFs and suspicion of liver dysfunction.

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