Identification of Risk Factors for Abnormal Postoperative Chemistry Labs after Primary Shoulder Arthroplasty

ABSTRACT:

Purpose

The purpose of this study was to determine patient-specific risk factors and clinical intervention rates for abnormal postoperative Chem-7 panels in shoulder arthroplasty patients.

Methods

Retrospectively, all primary anatomic total (aTSA) and reverse shoulder (RTSA) arthroplasties (between 2007-2013) performed at a single institution were identified. All patients underwent routine preoperative and postoperative day one (POD1) chemistry panels. Each clinically significant component of the Chem-7 panel was independently evaluated using a multivariate analysis to identify risk factors for abnormal results. Associated clinical intervention rates were also calculated.

Results

Data from 1,012 patients (248 RTSA; 764 aTSA) was analyzed. 5.4% of patients had at least one preoperative abnormal chemistry result. On multivariate analysis, patients with abnormal preoperative Chem-7 labs and a history of renal disease had significantly increased risk for abnormal POD1 labs ($p < 0.001$). Although 25.6% (259/1,012) of patients had at least one abnormal POD1 lab result, the total postoperative clinical intervention rate was 15.1% (39/259).

Conclusion

Renal disease and a preoperative abnormal chemistry result are important risk factors for abnormal postoperative Chem-7. Optimizing renal status and correcting abnormal blood

chemistry results preoperatively may reduce the incidence of abnormal postoperative chemistry results.

Level of Evidence: Level III

Introduction

The postoperative course following shoulder arthroplasty often involves routine postoperative laboratory testing on the day after surgery. Obtaining postoperative laboratory tests on all patients is often unnecessary; however, certain patient populations may be at higher risk for abnormal postoperative laboratory results (1, 2). The majority of studies that report laboratory test rates and utility have been in cardiac and intensive care patient populations, and have shown that, even when lab tests were abnormal, intervention rates were quite low(3-5).

Current literature has shown that both anatomical total shoulder arthroplasty (aTSA) and reverse total shoulder arthroplasty (RTSA), are well-tolerated procedures that can lead to successful clinical outcomes (6-8). Despite the fact that the vast majority of patients have an uncomplicated hospital course, patients often receive the same postoperative care. This includes a routine blood chemistry panel draw on the first postoperative day that consists of sodium (Na^{+}); potassium (K^{+}); chloride (Cl^{-}); carbon dioxide (CO_2); blood urea nitrogen (BUN); creatinine (Cr); and glucose. This current practice may be clinically unnecessary for many patients, increase the risk for harmful interventions due to false-positive values, and increase cost of care (2,3,6). The purpose of this study was three-fold: first, to report the rate of abnormal chemistry panel results in the perioperative period; second, to identify specific risk factors associated with those abnormal perioperative chemistry panel results; and third, to determine the postoperative clinical intervention rates for abnormal postoperative chemistry labs in a RTSA and aTSA surgical patient cohort.

Methods:

Following institutional review board approval, our electronic institutional database was searched between 2007-2013 for all cases of primary aTSA and RTSA. Patients were excluded if complete preoperative and postoperative blood chemistry was not available.

All patients underwent chemistry panel testing both preoperatively and on postoperative day (POD) 1. Results for individual components of the chemistry panel (Na+, K+, Cl-, CO2, BUN, Cr, and Glucose) were collected. Glucose results were excluded from the analysis because AccuCheck results, and not the glucose level from the chemistry panel, determined blood glucose management and associated clinical interventions. Additionally, Cl- and CO_2 results were excluded given that these tests were not utilized in the clinical decision making process in this patient cohort. Similarly, BUN and Cr values that were below the reference range were excluded as low values for BUN or Cr do not necessitate clinical interventions.

Reported clinical intervention rates associated with abnormal postoperative chemistry panels were collected via manual electronic medical record chart review. The most common clinical interventions were considered and included oral or intravenous NaCl or KCl repletion, fluid restriction, Kayexalate/Kalexate (Sodium-Polystyrene Sulfonate), hemodialysis, intravenous fluid boluses (500-1000 mL), and nephrology consultation.

A linear mixed model regression analysis was used to determine significant associations between abnormal perioperative Na+, K+, BUN, Cr laboratory results and potential risk factors. Risk factors considered included preoperative chemistry panel results, type of surgery, age, gender, and specific Charlson Comorbidity Index (CCI) parameters [acquired immune deficiency syndrome, metastatic cancer, diabetes mellitus (DM) with and without end organ damage, moderate or severe renal disease, liver disease, peptic ulcer disease, chronic pulmonary disease (CPD), dementia, cerebrovascular disease (CVD), peripheral vascular disease (PVD), congestive heart failure (CHF), myocardial infarction (MI), and rheumatic disease].

Results:

Demographics

After the initial review of the database, 1768 patients were identified. Following elimination of patients with incomplete data, 1,012 patients who underwent 764 (75.5%) primary aTSA and 248 (24.5%) RTA were included in the analysis. There were 447 (44.2%) males and 565 (55.8%) females with an average age of 67.6 (range: 18-94) and BMI of 29.7 (range: 12.1-59.1). The average Charlson Comorbidity index (CCI) was 3.8 (range: 0-8). Additional demographic information is summarized in Table I.

Blood Chemistry

There was at least one abnormal chemistry panel result in 5.4% of patients preoperatively and in 25.6% of patients on POD1. The most common abnormal preoperative laboratory results were low sodium, high BUN, and high BUN/Cr (16.5%, 8.4%, and 61.5%, respectively). The factors associated with low preoperative sodium (Table II) were male gender (OR= 1.458, p 0.039) and renal disease (OR= 2.103, p= 0.038). The factors associated with high preoperative BUN were older age (OR= 1.083, p< 0.001) and patients with CVD (OR= 10.488, p= 0.006), DM (OR= 3.796, p< 0.001), malignancy (OR= 6.085, p= 0.01), or renal disease (OR= 6.781, p< 0.001) (Table III). The risk factors associated with preoperative elevated Cr were: male gender (OR= 3.09, p=0.01), Diabetes Mellitus (OR = 3.9, p = 0.005), Diabetes Mellitus with end stage organ complications (OR = 5.5, p = 0.03), and Renal Disease (OR =38.02, p <0.001) (Table IV). The only factor associated with high preoperative BUN/Cr ratio was older age (OR= 1.036, p=0.001) (Table V).

Similar to preoperatively, the most common abnormal postoperative labs were low sodium (17.0%; 170/999) and high BUN/Cr ratio (35.0%; 348/993). Risk factors associated with low postoperative sodium (Table II) were CHF (OR= 1.377, p< 0.05), DMCM (OR= 11.909, p= 0.001), PVD (OR= 14.105, p= 0.002, and having a low preoperative sodium level (OR= 516.825, p< 0.001). Risk factors associated with high postoperative BUN/Cr ratio were age (OR= 1.025, p= 0.01, DM (OR= 1.962, p= 0.01, and a high preoperative BUN/Cr ratio (OR= 7.188, p< 0.001) (Table V).

Clinical Intervention for Abnormal Blood Chemistry

Although 25.6% (259/1,012) of patients had at least one abnormal POD1 lab result, the total postoperative clinical intervention rate was 15.1% (Table VI). Despite the relatively high incidence of low postoperative sodium (17%), there were no clinical interventions for hyponatremia. While the rates of postoperative hyperkalemia (3.3%, 33/999) and hypokalemia (4.4%, 44/999) were low, clinical intervention rates for hyper- and hypokalemia represented 87.4% of all interventions (Table VI). Renal disease was the only significant risk factor for high postoperative potassium laboratory results (OR= 9.071, p= 0.001).

Discussion:

Electrolyte imbalances if severe and untreated can manifest in devastating consequences such as cardiac arrhythmias, coma and sudden death; (1) however, signs and symptoms are most often minor and nonspecific including: nausea, lethargy, muscle weakness or cramps, and headache. Fortunately, major complications of electrolyte imbalances, the most common being associated with hyponatremia and hypokalemia, are rare following aTSA and RTSA. A paper by Jiang et al. evaluated perioperative complications of aTSA and RTSA, reporting that the rates of acute mental status changes, stroke, myocardial infarction, ileus, and death to be less than 0.5% (4). Because these complications are rare but potentially devastating, it would be worthwhile to identify those patients deemed high-risk for developing electrolyte imbalances. In this study, renal disease was the risk factor most commonly associated with abnormal labs. This is not surprising given the kidney's major role in fluid balance and excretion (9). Renal impairment would result in abnormal markers of kidney function (BUN and creatinine) and electrolyte imbalances.

Despite the frequency of abnormal postoperative chemistry panel results (25.6%), a low clinical intervention rate was associated with these abnormalities. There are a number of possibilities for this discrepancy. First, a lab is considered abnormal even if the value is one point outside the normal range. Therefore, the number at which a lab is considered abnormal from a reference standpoint is not necessarily that which is clinically relevant and requires intervention (1). Second, each individual patient is distinct, and a lab value must be taken in the context of the patient's demographics and preexisting comorbidities (1,10,11). For example, as a result of natural aging, renal function declines, leading to elevated baseline BUN and creatinine (11). Especially over the age of 70, BUN increases to levels higher than those of creatinine, leading to an elevated BUN/Cr ratio (12-14). This could possibly have contributed to the high percentage of elevated BUN/Cr in our study. Fifty-one percent of the patients with high preoperative BUN/Cr ratios and 55% of those with high postoperative BUN/Cr ratios were at least 70 years of age. Finally, physical exam findings must also be taken into account (1,10). An abnormal lab value may not be clinically significant if a patient is not showing symptoms of electrolyte imbalance For example, elevated BUN, Cr, or BUN/Cr ratio can signify dehydration; however, the patient may not be exhibiting any signs, making this lab finding clinically irrelevant (15,16).

One of the most common risk factors for abnormal postoperative lab results was having that same abnormal lab preoperatively. This was true for hyponatremia, high BUN, elevated creatinine, and high and low BUN/Cr ratios. It is important to note that the Spearman's rho values showed strong association between preoperative and postoperative values, especially for sodium, potassium, and creatinine (0.885, 0.885, and 0.952, respectively). Given these findings, we recommend increased vigilance in ordering postoperative chemistry panels for those patients with abnormal preoperative chemistry results or patients with renal disease. These two risk factors alone captured 78.8% (204/259) of the abnormal postoperative laboratory results. Further study will be necessary to assess the safety of eliminating routine laboratory testing for those patients without these risk factors.

This study has a several limitations. First, given that the study was retrospective, there were some inherent shortcomings in regard to data collection. We did not have access to the physician notes during the in-hospital period; therefore, it was not possible to have a full understanding of the decision-making process for each clinical situation. Additionally, some treatments can be used for multiple pathologies. For example, insulin can be administered for hyperglycemia or as a treatment for hyperkalemia. Due to the retrospective nature of this study, we were unable to determine the exact indication for each treatment, possibly leading to an overestimation of hyperkalemia intervention rates. Second, we searched for the most common clinical interventions that are used in the treatment of these electrolyte disturbances. It is possible that some physicians may have used less customary treatments. Third, because glucose values were excluded from analysis, the reported intervention rate may be less than at institutions that use the glucose value from the chemistry panel for proper glycemic control. Fourth, because this study evaluated patients from a single-institution with an average CCI of 0.6, it may not be representative of higher-risk patient populations at other surgical centers. Finally, though the sample size was relatively large, the event rates were small. This led to some risk factors having wide confidence intervals and potential for Type II error.

Conclusions:

The purpose of this retrospective study was to analyze the utilization of the blood chemistry panel in the postoperative setting following aTSA and RTSA by identifying patients at risk for abnormal postoperative electrolytes and the associated clinical intervention rates. The most consistent and strongest risk factors for abnormal POD1 blood chemistry results were preoperative abnormal blood chemistry results and renal disease. Based on our data, these two groups of patients appear most appropriate for POD1 blood chemistry and routine POD blood chemistry in patients without these risk factors may be unnecessary.

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Table Legend

Table I. Patient Demographics. BMI= Body Mass Index; Kg/m^2 = kilograms per meter squared; LOS = Length of Stay; TSA = Total Shoulder Arthroplasty; RTSA = Reverse Total Shoulder Arthroplasty; CCI= Charlson Comorbidity Index.

Table II. This table reports the factors that significantly increased the risk for abnormal preoperative sodium. CI = Confidence Interval; CHF = Congestive Heart Failure; DMCM = Diabetes Mellitus with end stage organ damage; PVD = Peripheral Vascular Disease; Na = sodium.

Table III. This table reports the factors that significantly increased the risk of high preoperative (top) and postoperative (bottom) BUN. CI = Confidence Interval; CVD = Coronary Vascular Disease; DM = Diabetes Mellitus.

Table IV. This table reports the risk factors that were significantly associated with elevated preoperative (top) and postoperative (bottom) creatinine values. CI = Confidence Interval; DM = Diabetes Mellitus; DMCM = Diabetes Mellitus with end stage organ damage; PVD = Peripheral Vascular Disease; Cr = Creatinine

Table V. This table reports the risk factors that were significantly associated with preoperative (top) and postoperative (bottom) abnormal BUN/Cr values. CI = Confidence Interval; DM = Diabetes Mellitus.

Table VI. Chemistry Panel Clinical Interventions. Clinical intervention rates for each abnormal chemistry panel parameter are reported by postoperative day 1 as well as for the total postoperative period. n = patient number; POD = postoperative da; IV= intravenous; mL = milliliters; CO_2 = carbon dioxide; BUN= blood urea nitrogen; Cr = creatinine.