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Rhabdomyolysis After Laparoscopic Nephrectomy

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ABSTRACT

Background and Objectives: Laparoscopic renal surgery has become a widely applied technique in recent years. The development of postoperative rhabdomyolysis is a known but rare complication of laparoscopic renal surgery. Herein, 4 cases of rhabdomyolysis and a review of the literature are presented with respect to pathogenesis, treatment, and prevention of this dire complication.

Methods: A retrospective review of over 600 laparoscopic renal operations over the past 8 years was performed. All cases of postoperative rhabdomyolysis were identified. A Medline search was performed to find articles related to the development of postoperative rhabdomyolysis. Cases of rhabdomyolysis developing after laparoscopic renal surgery and common risk factors between cases were identified.

Results: The incidence of postoperative rhabdomyolysis in our series is 0.67%. It is similar to the rate reported in other series. Male sex, high body mass index, prolonged operative times, and the lateral decubitus position are all risk factors in its development.

Conclusion: The prevention and optimal management of postoperative rhabdomyolysis following laparoscopic renal surgery has yet to be defined. The risk factors we identified should be carefully addressed and minimized. A better understanding of the pathogenesis of rhabdomyolysis will also be a key component in its prevention.

Key Words: Rhabdomyolysis, Laparoscopy, Acute renal failure, Prevention.

INTRODUCTION

Since the first laparoscopic nephrectomy was performed in 1991,¹ laparoscopic renal surgery has rapidly grown in scope and application. Today, this approach is being utilized for a variety of procedures from oncologic renal extirpation to renal reconstruction and donor nephrectomy. Herein, we report 4 cases of rhabdomyolysis following laparoscopic nephrectomy performed with the patient in a 45-degree lateral decubitus position. Rhabdomyolysis following nephrectomy appears to be a rare but potentially severe and debilitating complication. We reviewed the literature to determine the expected frequency of this complication and to produce a better understanding of its origins, treatments, and expected outcomes.

CASE REPORTS

Case One

A 36-year-old 163 kg male (body mass index [BMI] = 38.6) underwent a laparoscopic hand-assisted left donor nephrectomy while in a 45-degree right flank position with the kidney bar raised. Operative time was 6 hours. In the postanesthesia care unit, the patient complained of right lower back and buttock pain similar in nature to his previously experienced chronic lower back pain. Postoperative creatinine was 1.6 mg/dL, increased from his baseline of 1.0 mg/dL. This severe pain continued on postoperative day one, at which time the patient was also noted to have weakness in his right lower extremity, and a neurology consult was obtained. The patient's creatinine rose to 1.9 mg/dL. Additionally, the patient's urine was noted to be brown in color. Creatinine kinase levels were obtained and found to be markedly elevated at 126,539 IU/L, and a urine myoglobin test confirmed the presence of myoglobin in the urine. A diagnosis of rhabdomyolysis was made. Over the next 24 hours, the patient's urine output, which had been 1.3 L on both postoperative days 0 and 1, diminished to 325 mL, and his creatinine increased to 4.9 mg/dL. A diagnosis of oliguric acute renal failure was made, and a renal consult was obtained. Alkalinization of the urine with intravenous bicarbonate,

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hydration, and pharmacological diuresis (mannitol and furosemide) were ineffective in reversing the oliguric renal failure, and the patient would eventually require 4 weeks of dialysis. His lower extremity weakness improved; however, he required long-term physical therapy.

Case Two

A 33-year-old, healthy, 81.7 kg male (BMI = 28.3), underwent a laparoscopic hand-assisted left donor nephrectomy while in a 45-degree right flank position with the kidney bar raised. Operative time was 6.4 hours. The immediate postoperative course was significant for complaints of right lower back pain in the postanesthesia care unit. Urine myoglobin test on postoperative urine was positive, and creatinine kinase and creatinine levels obtained in the recovery room were found to be 2239 IU/L and 1.3 mg/dL, respectively. The patient's preoperative creatinine was 0.9 mg/dL. A diagnosis of rhabdomyolysis was made, and immediate intravenous hydration with bicarbonate-containing solution was begun. A nephrology consultation was obtained. Over the first 24 hours, the patient maintained adequate urine output (1.8 L). However, during the ensuing 24 hours, the urine output dropped to 687 mL followed by a further decline to 440 mL the next day. The patient's creatinine kinase level peaked at 50,973 IU/L. Additionally, over that time period, the patient developed increasing difficulty maintaining oxygenation due to volume overload. Continuous infusion of furosemide was unsuccessful in preventing renal failure in this patient, despite maintenance of reasonable urinary output. The patient's creatinine continued to rise to 11.7 mg/dL, at which point hemodialysis was initiated. He subsequently received 3 dialysis treatments, after which no further dialysis was required. Additionally, the patient continued to experience significant right lower back and buttock pain. The patient's pain resolved by postoperative week 6, and he returned to work without restrictions 8 weeks after surgery.

Case Three

A 60-year-old, 131 kg male (BMI = 45.3), with a history of asthma, bronchitis, hypertension, and chronic back pain who was found to have a left-upper pole renal mass was taken to the operating room for planned laparoscopic left partial nephrectomy. The patient's preoperative creatinine was 1.1. The patient was placed on the table in a 45-degree lateral decubitus position with the table flexed and the kidney bar raised. After exposure of the renal hilum, dissection was begun to expose the left upper pole mass. Dissection was somewhat difficult around the mass sec-

ondary to its close approximation to the adrenal gland. Nevertheless, over a short period of time during dissection of the tumor, the patient became increasingly difficult to ventilate. Specifically, the patient required increasingly elevated ventilatory pressures and demonstrated rising end-tidal CO₂ levels. The anesthesia team alerted the surgical team of this problem, and the abdominal insufflation and the operation were temporarily suspended while the ventilatory issues were corrected. After correction, an attempt was made to once again continue with the operation. However, shortly after reinstating abdominal insufflation, the patient again exhibited respiratory changes. Because it was thought that the patient could not tolerate continued insufflation for a prolonged period of time, the decision was made to perform a hand-assisted nephrectomy. Hand-port access was obtained, and nephrectomy was accomplished shortly thereafter. In the recovery room, the patient complained of significant right lower back and leg pain; his postoperative creatinine was 2.0 mg/dL. When this continued for several hours, a serum creatinine kinase level was obtained and found to be elevated to 33,140 IU/L. Urine myoglobin was positive. The patient's urinary output rapidly declined from 700 mL during the first 6 hours to 230 mL for the next 24 hours. Diuresis with furosemide and hydration with alkaline solution were instituted, but the patient progressed to acute oliguric renal failure. The patient required 5 dialysis treatments but subsequently recovered adequate renal function. The patient suffered prolonged right back and lower extremity pain, with marked weakness in his right upper leg.

Case Four

A 52-year-old, 145 kg male (BMI = 53), with a history of asthma, hypertension, and glaucoma with an incidentally detected 5.3-cm left renal mass underwent a laparoscopic left radical nephrectomy while in a rotated supine position. His preoperative creatinine was 1.1. Though dissection was difficult secondary to body habitus, laparoscopic nephrectomy was achieved in 3.5 hours, and the patient was returned to a supine position. Specimen extraction and wound closure were complete an hour later. The patient remained intubated until postoperative day #1 due to concerns over his asthma history and obesity. After extubation, the patient complained of right hip and right leg weakness. Rhabdomyolysis was suspected and confirmed by laboratory evaluation. Creatinine kinase level peaked on postoperative day #3 at 111,470 IU/L, and the patient progressed from oliguric renal failure to anuric renal failure, despite aggressive hydration, induced diure-

sis, and alkalinization of the urine. Serum creatinine peaked at 6.4 mg/dL before institution of dialysis. The patient required long-term dialysis and remained with severe lower extremity weakness at the time of the most recent follow-up (6 weeks).

DISCUSSION

Role of Risk Factors

Rhabdomyolysis and subsequent renal failure are well-known complications of trauma, particularly in the setting of a crush injury.² Additionally, it has been reported to occur in the postoperative setting as a complication of general surgical, orthopedic, and urologic procedures performed with the patient in the lithotomy position.²⁻⁴ At our institution, we have performed 600 laparoscopic nephrectomies over the past 8 years. We report 4 cases of rhabdomyolysis following laparoscopic nephrectomy over this time period. The incidence of rhabdomyolysis in our series is 0.67%. Three of these nephrectomies were performed with the patient in a 45-degree flank position with the table in the flexed position and the kidney bar raised; the last case was performed with the patient in a rotated supine position. Our patients exhibited many of the risk factors that have been often proposed to contribute to the development of rhabdomyolysis: male sex, elevated BMI, prolonged OR time, and procedure performed with the patient in the lateral decubitus or 45-degree lateral decubitus position.^{3,5,6} In reviewing the literature, we noted that all but 2 of the patients who developed rhabdomyolysis were male. Additional risk factors that have been suggested include preexisting renal disease, extracellular volume depletion, and renal hypoperfusion.⁵

Mechanisms of Rhabdomyolysis and Acute Renal Failure

The earliest association of rhabdomyolysis and renal failure was described in 1941.⁷ Since that time, a better understanding of the risk factors and pathogenesis of this condition have been achieved. In relating it to surgical positioning, it should be considered as representing part of the spectrum of local changes that can occur to skin and underlying soft tissues due to prolonged fixed pressure on these areas. As a disease process, rhabdomyolysis presents 2 separate problems, namely the local effects of tissue injury and the systemic consequences that result from that injury.²

In rhabdomyolysis occurring in the surgical setting, the predominant initial contributing factor is thought to be the ischemia or partial ischemia that results from direct, prolonged pressure on the soft tissues and overlying skin. Experiments by Whitesides⁸ have suggested that tissue ischemia may begin to occur when tissue pressures approach to within 10 mm Hg to 30 mm Hg of the diastolic pressure. Studies⁹ have shown that skeletal muscle tolerates this ischemia for as long as 2 hours, after which time ultrastructural ischemic changes begin to occur. As ischemia persists, these changes become more severe and are noted to be irreversible after about 7 hours. As the problems of pressure and time relate to laparoscopic renal surgery, it is clear why obesity, patient positioning, and operative time could play a role in the development of postsurgical rhabdomyolysis. In reviewing our reported cases and the literature, we would also question whether the additional insult of intraabdominal insufflation (generally 12 mm Hg to 15 mm Hg) might narrow what is already a small perfusion pressure window in our obese patients.

When surgical procedures are terminated and the direct pressure on the soft tissue beds is relieved, a secondary pathogenic process occurs in rhabdomyolysis. Ischemia-reperfusion injury in association with resulting localized tissue edema can result in a continued low perfusion state in the local tissue bed in addition to producing a systemic hypovolemia as intravascular fluids are lost through local capillary beds.² Further systemic effects are known to occur as myocyte damage leads to liberation of myoglobin into circulation with the potential development of myoglobinuria and subsequent acute renal failure.² These systemic effects can be particularly devastating in the setting of renal extirpative surgery where the relative renal hypoperfusion and large myoglobin load must be handled by a solitary renal unit.

Prevention of Rhabdomyolysis in Laparoscopic Renal Surgery

Table 1 lists, in addition to our present cases, all the cases of rhabdomyolysis that developed following laparoscopic renal surgery described in the literature.^{5,10-20} All published patient characteristics are included. The rarity of this complication is underscored by review of several large series of laparoscopic nephrectomy for which no cases of rhabdomyolysis were described.²¹⁻²⁵ For the cases described here, the incidence ranged from 0.4% to 4.9%.^{10,13,14} The incidence in our series is 0.67%. The data from our series confirm previously stated risk factors: male sex, long operative time, and high body-mass index. The

Table 1.
Patient Data From Known Cases of Rhabdomyolysis Following Laparoscopic Renal Surgery

Reference	BMI (mg/m ²)	Position	LOS (min)	Urine Discoloration	Pain	Serum Creatinine (mg/dL)		Peak CK (U/L)	Time to Dx (hrs)	Post-op Management	ARF	HD #Treatments	Intraop Blood Pressures
						Pre op	Post op						
Case 1	36.6	R-MLD	360	Yes	Yes	1.0	4.9	126 539	24	A/H/D	Yes	12	105–130/60–85 (Mean 114/70)
Case 2	28.3	R-MLD	384	Yes	Yes	0.9	11.7	50 973	2	A/H/D	Yes	3	113–140/90–60 (Mean 124/77)
Case 3	45.3	R-MLD	420	Yes	Yes	1.1	6.2	38 453	8	A/H/D	Yes	5	95–120/45–65 (Mean 100/54)
Case 4	50.5	R-MLD	210	Yes	Yes	1.1	6.4	111 470	24	A/H/D	Yes	Ongoing at last f/u	NA
10*	29	MIXED	378	NA	Yes	NA	NA	24 000	9.6	A/H	NA	NA	NA
11	31	R-MLD	285	NA	NA	1.2	17	101 000	NA	NA	NA	NA	NA
12	31	R-LD	510	Yes	NA	1.0	1.3	33 682	NA	H/D	NA	NA	NA
5	32.7	L-MLD	350	No	Yes	0.8	0.85	10 960	NA	None	No	0	NA
13	24	LD	490	Yes	NA	1.4	1.5	9 350	NA	A/D	Yes	NA	NA
	29.5	LD	360	Yes	NA	0.8	2.1	99 193	NA	A/D	Yes	NA	NA
	28.2	LD	398	Yes	NA	0.9	1.6	28 372	NA	A/D	Yes	NA	NA
	57.6	LD	495	No	NA	1.2	6.6	13 090	NA	D	Yes	NA	NA
	32.4	LD	566	Yes	NA	0.9	1.2	39 220	NA	None	No	0	NA
	42.3	LD	350	Yes	NA	1.0	9.7	22 053	NA	A/D	No	0	NA
	28.9	LD	387	Yes	NA	0.9	9.1	26 112	NA	A/D	No	0	NA
	32	NA	342	Yes	NA	NA	NA	NA	NA	NA	No	0	NA
14	28	NA	384	No	NA	NA	NA	NA	NA	NA	No	0	NA
	110 kg (wt)	R-LD	420	Yes	Yes	NA	NA	28 522	24	A/H/D	No	0	NA
16	34.6	NA	240	Yes	NA	1.3	8.8	75 690	NA	A/D	No	0	NA
17	32	R-LD	138	NA	NA	1.52	3.2	52 394	NA	NA	Yes	NA	NA
18	NA	MLD	311	Yes	NA	NA	NA	mild elevation	NA	A/H	No	0	NA
19	NA	LD	NA	Yes	NA	NA	NA	NA	<24	NA	Yes	Yes	NA
20	31	R-LD	280	NA	Yes	1.2	4.5	19 295	24	H	Yes	0	NA
Mean	33.2		368.7										

*Mean based on 6 patients.

†NA = not available; LD = lateral decubitus; MLD = 45° lateral decubitus flexed w/kidney bar; LOS = length of surgery; CK = creatinine kinase; A = alkalinization; H = hydration; D = diuretic; HD = hemodialysis.

average length of surgery for all reported cases of rhabdomyolysis that we identified in the literature is 368.7 minutes. Note should also be made of the fact that 9/28 (32%) of the cases of postlaparoscopic renal surgery rhabdomyolysis occurred following laparoscopic donor nephrectomy. It may be that this population is particularly susceptible to this complication, as the operative times may be longer and the patients may tend to be younger and with increased muscle mass compared with these things in renal cancer patients. Higher perfusion pressures or permissive hypertension may have provided improved

perfusion to the dependent soft-tissue beds and may have helped to prevent the development of rhabdomyolysis.

Another consideration in reviewing these data is table positioning and use of the kidney rest. Various positions have been demonstrated to put surgical patients at particular risk for rhabdomyolysis, including the lithotomy position and the lateral decubitus position.^{2–4,6,13,26–28} Three of the 4 patients in our series were placed in a 45-degree lateral decubitus position with a soft roll to support the upside hip and shoulder. Additionally, we previously put

the table in a slightly flexed position with the kidney bar raised. This modification likely produces more focused areas of pressure. After reviewing these cases, we changed our laparoscopic nephrectomy positioning. Currently, we have been utilizing a rotated supine position in which the patient is placed supine on the table with a sandbag placed under the shoulder and back ipsilateral to the side of the planned nephrectomy. The patient is then secured to the table, and the entire table is rotated to achieve dependency of the abdominal contents to facilitate dissection. The one patient who developed rhabdomyolysis while in this position had the highest BMI⁵³ and the shortest total operative time (3.5 hours), indicating that morbid obesity, even in the absence of an exaggerated position or prolonged operative time, may be the most significant risk factor for this devastating complication. The average BMI combining our series with others in the literature for patients who develop rhabdomyolysis is 33.2. Other authors¹¹ have suggested that early lowering of the kidney rest may help prevent this complication. Whether other devices such as vacuum “bean bags,” gel cushioning pads, or intraoperative pressure monitoring devices would be helpful in reducing pressure-related muscle ischemia remains to be seen. All of our patients also exhibited induration and erythema of the skin overlying the dependent muscle bed. These findings in concert with lower back or lower extremity pain should suggest the possibility of impending rhabdomyolysis. Investigation with serum creatinine kinase levels, urinalysis, microscopic evaluation, and urine myoglobin should confirm the diagnosis. Brown or reddish discoloration of the urine, while common in this setting, would not seem to be a reliable predictor of rhabdomyolysis or impending renal failure, as 3/20 (15%) of the patients did not exhibit this finding even though one of these 3 patients went on to develop renal failure. There was a tendency for the eventual development of acute renal failure in patients as peak creatinine kinase increased (average peak CK for renal failure group, $46\ 780 \pm 7200$ vs $25\ 650 \pm 15\ 100$ for those who did not develop acute renal failure). Presence of detectable levels of myoglobin in the urine as a predictor for renal failure could not be determined from these data.

Treatment recommendations for the prevention of renal complications from rhabdomyolysis generally include ample intravenous hydration to overcome hypovolemia and renal hypoperfusion; bicarbonate infusion to alkalinize the urine and improve myoglobin solubility; and induced diuresis to assist in flushing the myoglobin out of the renal tubules. Diuresis is generally induced with either mannitol

or furosemide, which has the potential disadvantage of causing acidification of the urine. Despite the use of hydration, alkalinization and diuresis, all of our patients required temporary dialysis. More specific guidelines as rhabdomyolysis relates to patients with a solitary kidney might be helpful in determining the optimum methods for preventing renal failure. With regards to limiting neuromuscular impairments that result from rhabdomyolysis, unfortunately, no good therapies are available. The role of fasciotomy in this circumstance is unclear.^{2,3} Many of these patients will need prolonged physical therapy and pain management to achieve a good functional outcome.

CONCLUSION

Rhabdomyolysis is a serious potential complication of laparoscopic renal surgery. The incidence ranges from 0% to 4.9%. Particular care to prevent this complication should be taken in patients with increased BMI and in those patients for whom a protracted operating room time is expected. Whether laparoscopic donor nephrectomy patients are at particular risk for this procedure remains to be seen, but ensuring ample padding and minimizing positioning time are presumptively the best ways to prevent this complication. Other considerations for preventing this complication include foregoing attempted laparoscopy in susceptible patients or early conversion to open nephrectomy in cases where progress is impeded. Furthermore, decreasing the time during which the table is flexed and the kidney bar raised may further diminish the chances of a patient developing rhabdomyolysis. Routine measurement of creatinine kinase and urine myoglobin levels in the recovery room for patients at high-risk of rhabdomyolysis may allow for the earlier detection of rhabdomyolysis, and, potentially a better outcome. Nevertheless, prevention of this complication should remain the primary goal. The next step would be to more thoroughly evaluate the precipitating events and primary risk factors for the development of rhabdomyolysis postoperatively. To that end, we are initiating a study at our institution to evaluate several intraoperative parameters that have been thought to play a role in the development of rhabdomyolysis. We hope that this will add to our understanding of the pathogenesis of this complication and ultimately its prevention.

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