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Postoperative creatine kinase elevation following hip arthroscopy and associated risk factors

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ABSTRACT

Objective: The aim of this study was to investigate postoperative CK and risk factors for CK elevation after hip arthroscopy.
Methods: This retrospective study reviewed 122 patients (50 males, 72 females; mean age, 44.1 years) who underwent hip arthroscopy from September 2012 to March 2018. For all patients, CK was investigated preoperatively, on postoperative days 1 and 3, and at postoperative weeks 1 and 2. Univariate and multivariate analysis was performed for parameters including sex, age, body mass index, preoperative glomerular filtration rate, diagnosis, duration of surgery, and duration of traction to determine the risk factors for CK > 10 upper limit of normal (CK > 10 ULN; 1900 IU/L for males and 1500 IU/L for females) after surgery.
Results: Mean CK was 104.7 ± 68.7 IU/L preoperatively and 839.2 ± 2214.0, 523.9 ± 1449.4, 186.0 ± 690.7, and 122.0 ± 307.1 IU/L on postoperative days 1 and 3 and at postoperative weeks 1 and 2, respectively. CK was significantly higher on postoperative days 1 and 3 than before surgery. In total, 11 patients (9.0%), including 8 males (16.0%) and 3 females (4.2%), had CK > 10 ULN. Younger age and longer duration of traction are independent risk factors for CK > 10 ULN.
Conclusion: After hip arthroscopy, CK levels should be monitored, especially in young patients and cases of prolonged duration of traction during surgery.
Level of evidence: Level IV, therapeutic study.

Introduction

Hip arthroscopy is performed for intra-articular pathologic conditions such as femoroacetabular impingement (FAI),[1] labral tear,[2] and hip dysplasia.[3] The procedure is regarded as less invasive than open surgical procedures,[4,5] but several complications have been reported including traction neuropraxia,[6] intra-abdominal or intra-thoracic fluid extravasation,[7] thromboembolic disease,[8] and femoral neck fracture.[9] Moreover, the soft tissue around the hip joint is considerably damaged because hip arthroscopy requires high-pressure traction of the lower extremity. In fact, in many cases of hip arthroscopy, the serum creatine kinase level (CK) increases rapidly. Because such soft tissue damage can cause complications such as rhabdomyolysis, monitoring using serum markers is considered necessary.

Postoperative CK elevation has been reported mainly following bariatric,[10–13] urologic,[14,15] and neurologic surgery,[16,17] and many of these reports define this phenomenon as rhabdomyolysis even in the absence of symptoms. During these surgeries, the high pressure exerted on muscles may cause postoperative rhabdomyolysis.[12,14–16] Similarly, the high interface pressure during hip arthroscopy by the considerable traction may damage the thigh and gluteal muscles, causing CK elevation. For this reason, we usually perform frequent blood tests before and after hip arthroscopy. Martin et al.

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investigated 30 patients who underwent hip arthroscopy and pointed out the effect of traction on CK elevation in addition to venous blood flow and nerve conduction.[18] Although they did not investigate the correlation between CK elevation and various other parameters that probably affect CK, investigating its risk factors is considered important.

We hypothesized that a longer duration of traction during hip arthroscopy might increase CK levels in the early postoperative period. The purpose of this retrospective study was to investigate CK levels after hip arthroscopy and to clarify risk factors for CK elevation.

Patients and methods

Patient selection

This study was approved by the institutional review board of our hospital. From September 2012 to March 2018, 159 patients underwent hip arthroscopy. Patients who were <15 years of age (n = 4), those who had undergone another surgical procedure simultaneously, such as rotational acetabular osteotomy or removal of internal fixation hardware (n = 29), and those who used statins preoperatively (n = 4) were excluded. There were no cases of patients who used corticosteroids, anticonvulsants, or antipsychotics, and none who suffered direct trauma, received intramuscular injections, or developed infections, which could be considered to cause increased CK within 3 months before surgery. Therefore, in this study, we evaluated 122 patients: 50 males and 72 females with a mean age at the time of surgery of 44.1 ± 13.7 (range: 15–70) years. In total, 28 patients had FAI, 38 had osteoarthritis (OA), and 56 had other diagnoses (46 had isolated labral tear, 6 had osteochondromatosis, 2 had a loose body, and 2 had ganglion).

Surgical procedure

Under combined general and spinal anesthesia, all patients were placed in the supine position on a traction table. Both legs were positioned in approximately 10° flexion, 10° abduction, and slight internal rotation (Fig. 1a). With a well-padded perineal bar as a fulcrum to provide counter traction (Fig. 1b), appropriate traction was applied through the hip to try to elicit the hip vacuum sign. Anterior, anterolateral, and lateral portals were placed under image intensifier guidance and direct vision. Ringer's lactate solution with the addition of 1 mg adrenaline per 3000 mL of fluid was used as arthroscopy fluid via arthroscopy pump. The pump pressure was set to 60 mmHg throughout the procedure. Synovitis, osteochondromatosis, labral tear, impingement lesion, and ganglion were all treated as needed. At the end of the procedure, the joint space was washed thoroughly.

Patient assessment

For all patients, CK was measured before surgery and on postoperative days (PODs) 1 and 3 and at postoperative weeks 1 and 2. CK reference values were 0–190 IU/L and 0–150 IU/L for male and female patients, respectively.

The following parameters were recorded for analysis: sex, age, body mass index (BMI), preoperative glomerular filtration rate (GFR), duration of surgery, and duration of traction. All parameters were compared to CK on POD 1. Then, to determine the risk factors for CK > 10 times the upper limit of normal (CK > 10 ULN; 1900 IU/L for males and 1500 IU/L for females)—which is the optimal definition of rhabdomyolysis according to several research bodies[19–21]—patients were assigned to a group with CK > 10 ULN (WT group) or a group without CK > 10 ULN (WO group) postoperatively. First, in univariate analysis, each parameter was compared between the groups, and then multivariate analysis was carried out. In addition, each parameter was compared according to diagnosis (FAI, OA, and other). A diagnosis of FAI was made based on radiographic findings of cam, pincer, and combined impingement, and clinical findings of anterior hip pain aggravated by hip flexion and rotation. The diagnosis of OA was made based on radiographic findings of Kellgren–Lawrence grade ≥2.

Statistical methods

The paired *t*-test was used for comparisons of mean CK over time. To assess the relationship between CK on POD 1 and various parameters, we used Mann–Whitney *U* test (for sex) and Pearson's correlation coefficient (for other parameters: age, BMI, GFR, duration of surgery, and duration of traction). To examine risk factors for CK > 10 ULN, Fisher's exact test was used to compare sex and Mann–Whitney *U* test was used to compare other parameters for univariate analysis, and stepwise logistic regression was used for multivariate analysis. Receiver operating characteristic (ROC) curve analysis was used to identify the optimal cut-off value. For comparison according to diagnosis, Fisher's exact test with Bonferroni post-hoc test (sex) and Kruskal–Wallis test with Steel–Dwass post-hoc test (CK on POD 1 and other parameters) were used. A post-hoc test was performed only when a significant difference was detected between the groups using an overall test. For all statistical tests, $p < 0.05$ was considered significant.


(a)


(b)

Fig. 1. Hip arthroscopy procedure in this study. a. The patient is placed in the supine position on a traction table with both legs positioned in approximately 10° flexion, 10° abduction, and slight internal rotation. b. A well-padded bar is placed just inferior to the perineum as a fulcrum to provide counter traction.

Results

Mean CK value over time

Mean CK was 104.7 ± 68.7 IU/L before surgery and 839.2 ± 2214.0, 523.9 ± 1449.4, 186.0 ± 690.7, and 122.0 ± 307.1 IU/L on PODs 1 and 3 and at postoperative weeks 1 and 2, respectively. CK was significantly higher on PODs 1 and 3 than before surgery ($p < 0.001$ and $p = 0.001$, respectively; Fig. 2). CK on POD 1 was <500 IU/L in 88 cases (72.1%), 500–1000 IU/L in 18 (14.8%), 1000–5000 IU/L in 12 (9.8%), 5000–10,000 IU/L in 2 (1.6%), and >10,000 IU/L in 2 (1.6%), with a mean value of 1572.6 ± 3296.4 IU/L for males and 329.9 ± 460.8 IU/L for females.

Relationship between CK on POD 1 and parameters

Mean values were BMI 23.2 ± 3.8 kg/m^2, GFR 78.4 ± 14.7 mL/min, duration of surgery 181.6 ± 56.5 min, and duration of traction 110.3 ± 61.9 min. Correlation coefficients between CK on POD 1 and various parameters were as follows: age ($r = -0.241$, $p = 0.007$), BMI ($r = 0.041$, $p = 0.655$), GFR ($r = 0.150$, $p = 0.099$), duration of surgery ($r = 0.366$, $p < 0.001$), and duration of traction ($r = 0.372$, $p < 0.001$). Age, duration of surgery, and duration of traction showed weak correlations with CK on POD 1.

Risk factors for CK > 10 ULN

In total, 11 patients (9.0%), including 8 males and 3 females, had CK > 10 ULN. Therefore, the number of patients in the WT group was 11, and that in the WO group was 111. According to univariate analysis, the proportion of males in the WT group relative to all males (8 in 50 cases) was significantly higher than the proportion of females in the WT group relative to all females (3 in 72 cases) (16.0% vs 4.2%, $p = 0.049$; odds ratio [OR]: 4.327; 95% confidence interval [CI]: 0.971–26.718). Mean age was significantly lower in the WT group than in the WO group (33.3 ± 15.9 vs 45.2 ± 13.0 years, $p = 0.018$). On the other hand, no significant differences between the groups were seen in BMI (22.9 ± 2.4 vs 23.2 ± 4.0 kg/m^2, $p = 0.929$), GFR (83.3 ± 20.4 vs 77.9 ± 14.0 mL/min, $p = 0.408$). However, mean duration of surgery and duration of traction were significantly longer in the WT group than in the WO group (255.5 ± 42.9 vs 174.2 ± 52.4 min and 217.0 ± 52.3 vs 99.7 ± 52.1 min, respectively, both $p < 0.001$; Table 1).

According to multivariate analysis, younger age ($p = 0.002$; OR: 0.884; 95%CI: 0.817–0.957), and longer duration of traction ($p < 0.001$; OR: 1.040; 95%CI: 1.020–1.060) were independent risk factors for CK > 10 ULN (Table 2). Using ROC curve analysis, the optimal cut-off value for age was 38.0 years with a sensitivity of 72.7%, specificity of 73.9%, and area under the curve of 0.717 (95%CI: 0.522–0.912). The optimal cut-off value for duration of traction was 142.0 min with a sensitivity of 100.0%, specificity of 87.4%, and area under the curve of 0.948 (95%CI: 0.908–0.987).

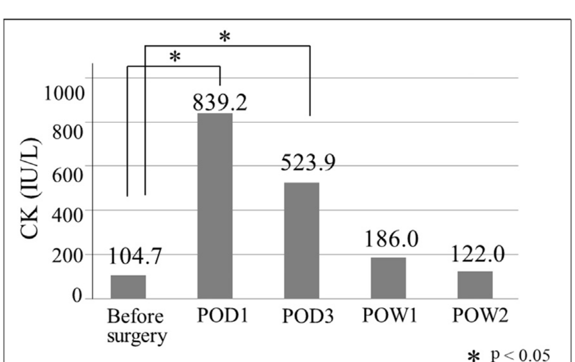

Fig. 2. Changes in mean serum CK level over time. CK is significantly higher on postoperative days 1 and 3 than before surgery. CK, creatine kinase; POD, postoperative day; POW, postoperative week. *p < 0.05.

Comparison according to diagnosis

Mean CK on POD 1 in the FAI, OA, and other group was 1804.0 ± 3863.4, 976.0 ± 1942.7, and 264.0 ± 306.3 IU/L. Although both the FAI and OA groups had significantly higher levels than the other group ($p < 0.001$), no significant difference was seen between the FAI and OA groups ($p = 0.537$).

The proportion of males in the FAI, OA, and other group was 23 cases (82.1%), 11 cases (28.9%), and 16 cases (28.6%). Mean age was 33.3 ± 12.8 in FAI, 54.6 ± 9.0 in OA, and 42.4 ± 11.8 years in other; the respective mean BMIs were 25.2 ± 3.4, 22.5 ± 3.6, and 22.7 ± 4.0 kg/m^2; the respective GFRs were 85.3 ± 17.0, 73.3 ± 13.4, and 78.3 ± 13.0 mL/min; the respective durations of surgery were 207.1 ± 52.8, 207.4 ± 51.3, and 151.2 ± 46.3 min; and the respective durations of traction were 99.7 ± 73.6, 131.9 ± 72.2, and 100.9 ± 42.4 min. For all parameters, there were significant differences among the 3 groups (Table 3).

None of the patients developed cardiac arrest, compartment syndrome, or acute renal failure. Also, no patients developed any complications related arthroscopy such as traction neuropraxia, intra-abdominal or intra-thoracic fluid extravasation, thromboembolic disease, or femoral neck fracture.

Discussion

In this study, CK on POD 1 after hip arthroscopy exceeded 10 ULN in 11 of 122 patients (9.0%). CK can be readily measured and is the most sensitive enzyme marker for muscle damage, in suspected rhabdomyolysis.[19] The definition of rhabdomyolysis is still controversial. However, the most commonly recommended definition is CK exceeding 10 times the upper limit of normal.[20–22]

Although muscle damage is usually a result of direct trauma, it can be caused by drugs (e.g., antihyperlipidemics,[21] anticonvulsants,[23] and antipsychotics[24]) and in a few reported cases by surgical procedures.[10–17] Severe obesity in bariatric surgery,[10] and prolonged lithotomy position and flexed lateral decubitus position in urologic[14,15] and neurologic surgery[16,17] may confer increased risk of muscle compression. It appears that muscle ischemia due to compression of the lumbar and pelvic muscles results in muscle injury.[10,14] A similar mechanism may occur with hip arthroscopy because high-pressure traction is necessary during the procedure. Although the present study did not include traction force measurement, according to a report stating that comparable traction was applied until the vacuum sign was obtained, the force was between 200 and 300 N.[25] Such high interface pressure may injure the thigh and gluteal muscles even in the absence of high BMI or extreme surgical positioning. Although several other surgical procedures require lower extremity traction, such as those for the repair of femoral neck or femoral trochanteric fracture, there have been no reports of rhabdomyolysis following these surgeries. This is probably because hip arthroscopy involves greater traction force and longer surgery.

In this study, both longer duration of surgery and duration of traction were determined to be the risk factors. Several authors have mentioned a correlation between duration of surgery and CK elevation.[11,12,17] In patients with normal body weight, Poli et al. proposed that surgery exceeding 7 h was the only risk factor for a significant increase in CK.[17] On the other hand, in bariatric surgery,

Table 1
Univariate analysis of the WT (CK > 10 ULN) and WO groups (CK not > 10 ULN).

	WT (n = 11)	WO (n = 111)	P-value	Odds ratio	95% Confidence interval	
					Lower	Upper
Sex [c]						
Male (n = 50)	8 (16.0%)	42 (84.0%)	0.049[a,*]	4.327	0.971	26.718
Female (n = 72)	3 (4.2%)	69 (95.8%)				
Age (years)[d]	33.3 ± 15.9	45.2 ± 13.0	0.018[b,*]			
BMI (kg/m^2)[d]	22.9 ± 2.4	23.2 ± 4.0	0.929[b]			
GFR (mL/min)[d]	83.3 ± 20.4	77.9 ± 14.0	0.408[b]			
Duration of surgery (min)[d]	255.5 ± 42.9	174.2 ± 52.4	<0.001[b,*]			
Duration of traction (min)[d]	217.0 ± 52.3	99.7 ± 52.1	<0.001[b,*]			

CK: creatine kinase.
UNL: upper limit of normal.
BMI: body mass index.
GFR: glomerular filtration rate.
*P < 0.05.
[a] Fisher's exact test.
[b] Mann–Whitney *U* test.
[c] Values are given as the number of patients (percentage).
[d] Values are given as the mean ± standard deviation.

Table 2
Risk factors for CK > 10 ULN by multivariate analysis.

	P-value	Odds ratio	95% confidence interval	
			Lower	Upper
Age	0.002	0.884	0.817	0.957
Duration of traction	<0.001	1.040	1.020	1.060

CK: creatine kinase.
UNL: upper limit of normal.

Tolone et al. reported that surgery exceeding 230 min was the sole significant risk factor for CK elevation and stated that bariatric patients have a higher risk of CK elevation even with a shorter duration of surgery.[12] In hip arthroscopy, due to the considerable force exerted by lower extremity traction, high compressive pressure of the muscles may be similar to that in bariatric surgery. Therefore, not only longer duration of surgery but also duration of traction may be a risk factor for CK elevation.

Younger age was identified as an independent risk factor for CK > 10 ULN in this study. Similarly, male sex is also risk factor, although it is not independent risk factor. Previous studies in bariatric surgery have also suggested both factors conferred an increased risk of CK elevation.[10,12,13] Further support is provided by the fact that younger individuals and men in particular have larger muscle mass.[26] Thus, performing hip arthroscopy in younger male patients would likely be more demanding and involve higher interface pressure, causing more extensive muscle damage. In contrast, although several studies of bariatric surgery report high BMI as a possible risk factor,[10,11] the present study did not find any such correlation. This may be because this study did not include any patients with extremely high BMI such as those who required bariatric surgery. Similarly, low GFR was not a risk factor for CK elevation in this study. The reason for this finding may be that, although patients included those of advanced age (maximum 77 years), cases with considerably low GFR were not included (minimum 52.8 mL/min) in this study. However, in cases of extremely low GFR, caution might be

Table 3
Comparison according to diagnosis.

	FAI (n = 28)	OA (n = 38)	others (n = 56)	P-value			
				overall	FAI vs OA	FAI vs others	OA vs others
CK on POD 1	1804.0 ± 3863.4	976.0 ± 1942.7	264.0 ± 306.3	<0.001[a,*]	0.537[c]	<0.001[c,*]	<0.001[c,*]
Sex [e]							
Male (n = 50)	23 (82.1%)	11 (28.9%)	16 (28.6%)	<0.001[b,*]	<0.001[d,*]	<0.001[d,*]	1.000[d]
Female (n = 72)	5 (17.9%)	27 (71.1%)	40 (71.4%)				
Age (years)[f]	33.3 ± 12.8	54.6 ± 9.0	42.4 ± 11.8	0.006[a,*]	<0.001[c,*]	0.004[c,*]	<0.001[c,*]
BMI (kg/m^2)[f]	25.2 ± 3.4	22.5 ± 3.6	22.7 ± 4.0	0.002[a,*]	0.008[c,*]	0.003[c,*]	0.994[c]
GFR (mL/min)[f]	85.3 ± 17.0	73.3 ± 13.4	78.3 ± 13.0	0.011[a,*]	0.018[c,*]	0.143[c]	0.150[c]
Duration of surgery (min)[f]	207.1 ± 52.8	207.4 ± 51.3	151.2 ± 46.3	<0.001[a,*]	0.941[c]	<0.001[c,*]	<0.001[c,*]
Duration of traction (min)[f]	99.7 ± 73.6	131.9 ± 72.2	100.9 ± 42.4	0.029[a,*]	0.047[c,*]	0.310[c]	0.159[c]

CK: creatine kinase.
POD: postoperative day.
FAI: femoroacetabular impingement.
OA: osteoarthritis.
BMI: body mass index.
GFR: glomerular filtration rate.
*P < 0.05.
[a] Kruskal–Wallis test.
[b] Fisher's exact test.
[c] Steel–Dwass test.
[d] Bonferroni's test.
[e] Values are given as the number of patients (percentage).
[f] Values are given as the mean ± standard deviation.

necessary. On the other hand, investigating according to diagnosis is necessary because the surgical procedure varies with diagnosis. Indeed, significant differences were seen in CK levels on POD 1 according to diagnosis. However, in the present study, all the demographic data (sex, age, BMI, GFR, duration of surgery, and duration of traction) also differed significantly among diagnosis, so it is difficult to consider diagnosis as a risk factor.

In a study of total hip arthroplasty, Poehling-Monaghan et al. reported that postoperative levels of serum markers including CK cannot predict pain or functional outcomes.[27] In arthroscopic surgery, CK elevation to some extent is usually not a problem. However, there are case reports of rhabdomyolysis leading to acute renal failure following knee[28] and shoulder[29] arthroscopy. Although rhabdomyolysis-related hip arthroscopy has not been reported, rhabdomyolysis likely occurs more readily after hip arthroscopy compared with knee and shoulder arthroscopy because of the considerable force of traction in hip arthroscopy. Therefore, CK measurement is considered to be needed on days 1–3 particularly after hip arthroscopy, especially in young patients and patients requiring longer duration of traction during surgery, in order to prevent the onset of severe complications.

This study has several limitations. First, the standard deviations of postoperative CK are very high. Such dispersion might decrease the accuracy. Second, traction forces, which may influence the development of CK elevation, were not available for analysis. Third, we used an arthroscopy pump. Although none of the patients presented with obvious symptoms of compartment syndrome, the influence of extravasation, which could also account for elevated CK levels, cannot be ruled out. However, in this study, immediate postoperative magnetic resonance imaging was not performed and the thigh circumference was not measured.

Conclusions

CK was significantly higher on days 1 and 3 after hip arthroscopy than before surgery, and in 9.0% of cases, CK exceeded 10 ULN. Younger age and longer duration of traction were identified as independent risk factors for CK elevation. CK measurement is considered desirable after hip arthroscopy especially in young patients and those who require a longer duration of traction during surgery.

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Conflict of interest

All of the authors state that there is no conflict of interest.

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