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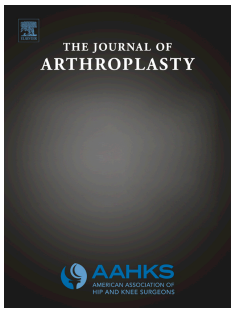

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Cryotherapy with Dynamic Intermittent Compression Improves Recovery from Revision Total Knee Arthroplasty

Effectiveness of cryotherapy with dynamic intermittent compression in rTKA

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ABSTRACT

Purpose : The goal of this study was to Assess the efficacy of cryotherapy with dynamic intermittent compression (CDIC) in Relieving post operative pain, decreasing blood loss and improving functional scores after revision total knee arthroplasty (rTKA).

Methods: we conducted a prospective case-control study. (Level of evidence: I) to evaluate the efficacy of CDIC on postoperative bleeding, pain and functional outcomes after rTKA. 43 cases were included at a single institution and divided in two groups: a control group without CDIC (n = 19) and an experimental group with CDIC (n = 24).Bleeding was evaluated by calculating total blood loss; pain at rest was evaluated with a visual analogue scale (VAS) on postoperative day 3; function was assessed using the Oxford score at 6 months postoperative. The comparative analysis was performed using Fisher's exact test

Results: The CDIC group had significantly lower total blood loss (260 ml vs 465 ml, $P < 0.05$), significantly less pain on day 3 (1 vs 3, $P < 0.05$) and a significantly higher functional score (42 vs 40, $P < 0.05$) than the control group.

Conclusion: This is the first report dealing with the use of CDIC after rTKA. According to our results , it improves the recovery of patients who underwent revision TKA, thus it should be integrated into our daily practice.

INTRODUCTION

Revision total knee arthroplasty (rTKA) procedures cause blood loss. Postoperative anaemia is associated with a higher risk of infection [7], of patient dissatisfaction [9] and postoperative blood transfusion with its inherent risks [23].

Revision TKA is a major orthopaedic procedure that causes soft tissue damages which contribute to localised pain, which in turn reduces range of motion and causes persistent quadriceps atrophy [25]. Significant blood loss after this procedure (up to 1.5 L) can lead to systemic complications [23]. Despite progress in multimodal analgesia and anaesthetic methods, knee arthroplasty is a painful surgery [25]. Non-pharmacological treatments can also play a role, most notably cryotherapy which decreases the local metabolism, thereby reducing blood loss and pain [13]. This technique has minimal disadvantages relative to its potential benefits [11].

New devices that combine cryotherapy with dynamic intermittent compression (CDIC) have recently been introduced. These devices provide a dry cold and maintain a consistent temperature for an extended period of time [24, 25]. While the benefits of these systems were demonstrated in primary TKA [24] and anterior cruciate ligament reconstruction [17], we did not find any published studies evaluating the effect of CDIC in patients undergoing revision TKA.

Our hypothesis was that use of CDIC would reduce total blood loss after revision TKA. The main objective of this study was to assess its efficacy in terms of postoperative blood loss. Patients who underwent rTKA were split into two matched groups for comparisons: one group with CDIC and the other one without. The other objectives were to compare the blood transfusion rate, the pain, the functional scores and the complication rate in both groups.

PATIENTS AND METHODS

This was a single-institution, prospective case-control study (Level of evidence: III). It was approved by our hospital's research ethics committee (Number 01-0115).

Patients

All patients who underwent single-stage rTKA from January 2013 to January 2015 were included.

Patients were excluded when a two-stage revision or a partial revision was performed. They were also excluded if they had a contraindication to CDIC, such as history of deep vein thrombosis, a coagulation disorder or skin damage at the device application site.

Forty-three patients were included (27 males, 16 females). The revisions procedures were carried out with a rotating hinge knee prosthesis (RHK Nexgen®, Zimmer, Warsaw, USA) in all cases. A tibial tubercle osteotomy was needed in 9 cases and the patella was resurfaced in 14 cases during the revision procedure.

The anaesthesia and postoperative analgesia protocols used were standardised and similar in the two groups. Anticoagulant therapy was initiated 6 hours after the end of surgery in all patients.

The procedure was performed with a tourniquet in all cases. It was released before closing the wound to realize complete haemostasis. The mean procedure duration was 120 minutes (90–140).

Methods

The population was divided into two groups: a control group without CDIC and an experimental one with CDIC. The demographics data in these two groups were comparable (Table 1). The patients in the control group were included between January 2013 and April 2014. The patients in the CDIC group were included between May 2014 and January 2015.

The CDIC device used was the Game Ready® system (CoolSystems Inc., Concord, CA, USA). It comes with an anatomical wrap that is applied to the knee. This wrap circulates pre-cooled compressed air and water. The temperature-controlled unit generates a dry cold; this is more comfortable for the patient than wet cold, thereby limiting the risk of maceration, bandage deterioration and skin lesions. The wrap is covered with a removable, washable cover for the patient's health and comfort. The wrap is connected to a portable control unit. The compression is applied intermittently depending on the protocol selected. The surgery support staff was given specific training on how to use the CDIC.

The following protocol was used:

- Application: after bandaging, in the operating room and before transfer to recovery room
- Intensity: programme 3 (30 minute on/off cycles)
- Temperature: 8°C
- Application duration: two 8-hour cycles over a 24-hour period
- Treatment duration: 72 hours postoperative

The control group was treated with regular cold application (4 hours per day) using a cold pack.

The following parameters were measured in both groups: total blood loss, haemoglobin and haematocrit levels on D-1, D+1 and D+5, transfusion volume and rate (red cell concentrate (RCC) units), pain on postoperative day 3, functional outcomes based on the Oxford score at 6 months postoperative and the number of complications recorded at 6 months postoperative.

Total blood loss was calculated using the preoperative (D-1) and postoperative (D+5) laboratory test results according to the Merculiari formula [8]:

Total blood loss = VST x (Hct_{pre}−$Hct_{post\ D5}$) + volume of retransfused RCC*

where the patient's total blood volume = $k_1 \times \text{height (m)}^3 + k_2 \times \text{mass (kg)} + k_3$

for men: $k_1 = 0.3669$, $k_2 = 0.03219$, and $k_3 = 0.6041$;

and for women: $k_1 = 0.3561$, $k_2 = 0.03308$, and $k_3 = 0.1833$

Hct_{pre} = initial preoperative Hct

$Hct_{post\ D5}$ = Hct on the morning of the 5th postoperative day

When transfusion was done (allogenic or autologous), the total blood loss was equal to the blood loss calculated from the change in haematocrit plus the volume transfused [14].

The indication for RCC transfusion in our surgical unit is standardised to Hb < 8 g/dL and/or patient with symptomatic anaemia.

Postoperative pain at rest was measured by the surgery unit's nurse using a visual analogue scale (VAS) on the 3rd day postoperative and by looking at the cumulative morphine use on the 5th postoperative day, expressed in morphine-equivalent dose (in mg).

The Oxford score [4] was collected pre- and postoperatively using the validated French version of the questionnaire [5]. The questionnaire was filled out during a follow-up visit 6 months after the procedure.

Statistical analysis

Cohort characteristics are presented as numbers, means, SDs, and ranges. The normal distribution of the data was assessed using the Kolmogorov–Smirnov test. For variables that were not normally distributed, data were analysed using the Mann-Whitney test for independent samples and the Wilcoxon signed rank test for dependent samples. Comparison of observed proportions was performed using Fisher's exact test. Statistical analysis was carried out using SPSS 18 Statistical Software (SPSS Inc, Chicago, IL, USA) and significance was set at *P* less than 0.05.

RESULTS (Table2)

Bleeding

The total blood loss was lower in the CDIC group than in the control group (260 ml vs 465 ml, $P < 0.05$). The haemoglobin and haematocrit levels were similar between groups. The transfusion rate was lower in the CDIC group (8% vs 42%, $P < 0.05$) and the mean lowest Haemoglobin level was lower in the control group with 8.5 gm/dL (+/- 1,2) vs 9,6 (+/- 1,6) ; $p < 0,005$. In the CDIC group, the number of RCC units given per patient was lower as well. No differences were found in any of the other measured blood-related parameters.

Pain

Pain at rest on day 3 was lower in the CDIC group than in the control group (1 vs 3, $P < 0.05$). The cumulative morphine intake at day 5 was not significantly different between groups.

Functional scores at 6 months

The Oxford score at 6 months postoperative was higher in the CDIC group than in the control group (42 vs 40).

Complications

There were four complications in the CDIC group and three in the control group. There were two cases of infection recurrence and one case of deep vein thrombosis in each group, and one case of extensor mechanism disruption in the CDIC group.

DISCUSSION

Our hypothesis was confirmed. The patients in the CDIC group had lower total blood loss than patients in the control group. Moreover, the transfusion rate and the pain were lower in the CDIC group. The functional outcome was similar between the two groups at 6 months postoperative.

This is the first study to evaluate the use of CDIC after revision TKA. The blood loss was evaluated using a method previously validated for revision TKA patients [22]. This method provides a complete view of the total blood loss, as it also takes into account hidden blood loss following TKA [23]. We did not use the blood volume present in the suction drains, as in other studies [16]. This blood loss calculation method is not reliable; it overestimates blood losses and can lead to more blood transfusions [19]. The volume of blood in surgical drains has never been validated as being an objective measure of blood loss [22]. There is no correlation between the volume of blood in the drains and the need for transfusion [15].

CDIC has been used in the sports medicine setting to improve recovery and to treat ligament and bone injuries [15, 17]. It has been shown that CDIC improves postoperative recovery by stimulating the tissue repair process [3]. Generally, these systems are provided to healthy athletes undergoing a minor procedure compared to revision TKA. We believe that any help is beneficial to a fragile population such as the one undergoing revision TKA.

The contribution of CDIC to postoperative recovery from TKA has already been demonstrated. Su et al [24] evaluated CDIC in patients undergoing primary TKA and compared it to a control group. In that study, the patients in the CDIC group used the system for 5 days after the procedure. They found a lower narcotic intake and slight improvement in the functional outcome in the patients using CDIC. We also found a tendency of reduced narcotic use (−20 mg morphine-equivalents in the CDIC group). This reduced narcotic intake reduces

the side effects inherent to these agents. Patients feel less medicated and have a better postoperative course. Advanced cryotherapy was compared to icing only in the postoperative course of TKA in a randomised controlled trial [25]. The authors concluded that there were no advantages in using advanced cryotherapy in daily practice, particularly because of the additional cost associated with these systems. However, more than one kind of cryotherapy system was used in that study, leading to variability in the results. Moreover, the blood loss was measured only through haemoglobin variations, which does not take into account hidden blood loss [23]. Additionally, no blood transfusions were performed, as the patients were undergoing primary TKA. The need for transfusion is higher during revision TKA [2].

Other therapeutic means have been proposed to reduce bleeding during primary and revision TKA procedures. Tranexamic acid has been shown to be effective in hip and knee arthroplasty [1]. Use of thrombin-based topical haemostatics does not have clear-cut benefits. One group has described its benefits in revision TKA [22]; however, anaemia, atrial fibrillation, infection have been associated with this type of product [12, 16, 18, 21]. These side effects do not come into play when using CDIC. Thienpont et al [25] bring up the risk of frostbite in the area where CDIC is applied. This is an extremely serious complication that would require an additional major soft tissue procedure [6]. We have not encountered this complication, and have not found any documented cases of frostbite with CDIC.

The current study has certain limitations. Firstly, this was a multi-surgeon study which increases the variability of the results. However, this also means that the study can be more easily generalised to current practice. Secondly, this study was performed within a highly specialised TKA surgery unit. Because of the use of advanced anaesthesia procedures, analgesic infiltration and preventative multimodal pain management [11], it is possible that a type II error occurred in our interpretation of the results. However, the anaesthesia and analgesia techniques did not differ between the control and CDIC groups. Moreover, the transfusion rate – likely the most relevant criteria from a clinical point of view – is subjected to confounding factors because of the patients' co-morbidities. Although we use a standardised approach, this bias is still present.

Conclusion

The number of revision TKA procedures performed each year will continue to increase [10, 20, 22]. Since CDIC improves the recovery of patients undergoing revision TKA, it should be integrated into our daily practice. Prospective randomised trial is necessary to validate the results of our study.

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Table 1 Baseline characteristics and surgery related data for the cohort
TT: tibial tubercle, BMI: Body mass index, ASA: American Society of Anesthesiologists

		Control group (n=19)	CDIC group (n=24)	P
Baseline characteristics	Mean (SD) Age, years	66.5 (9.7)	70 (13.9)	0.86
	Sex ratio : F/M	8/11	8/16	0.78
	Mean (SD) BMI, kg/m^2	29.7 (4.6)	29.7 (4.7)	0.89
	Pré op anticoagulants, n (%)	6 (32)	3 (13)	0.15
	ASA score, n (%)	1: 1 (5) 2: 8 (42) 3: 10 (53)	1: 4 (17) 2: 14 (58) 3: 6 (25)	0.17
Surgery-related data	Mean (SD) Surgery time, min	120 (40.2)	118 (43.3)	0.84
	Mean (SD) Tourniquet time	98 (27.4)	100 (29.3)	0.98
	TT osteotomy, n (%)	5 (26)	4 (17)	0.48
	Patella resurfacing, n (%)	8(42)	6(25)	0.39

Table 2 Summary of variables measured in both groups.
RCC: red cell concentrate, Hb: haemoglobin, Hct: haematocrit, VAS: visual analogue scale

		Control group (n=19)	CDIC group (n=24)	P
Blood loss	Mean (SD) Hb at D-1 (g/dL)	12.5 (2.1)	13 (1.8)	0.76
	Mean (SD) Hb at D+5 (g/dL)	10.4 (1.2)	10.7 (1.3)	0.31
	Mean (SD) Hct at D-1 (%)	37 (5.9)	39.6 (4.9)	0.9
	Mean (SD) Hct at D+5 (%)	31 (3.6)	32.7 (3.6)	0.19
	Mean (SD) Total blood loss (ml)	465 (275)	260 (106)	**0.024**
	Mean lowest Hb level	8.5	9.6	**0.03**
	Transfusion rate	42%	8%	**0.013**
Transfusion	Number of RCC units	0: 58% (n=11) 1: 5% (n=1) 2: 26% (n=5) 3: 11% (n=2)	0: 92% (n=22) 1: 0% (n = 0) 2: 4% (n=1) 3: 4% (n=1)	**0.023**
Pain	Mean (SD) VAS Day +3	3 (1)	1(1)	**0.01**
	Mean (SD) Narcotic consumption at Day +5 (mg)	100 (37)	80 (37)	1
Functional score	Mean (SD) Oxford	40 (2.8)	42 (2.4)	**NS**