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ORIGINAL ARTICLE

Cryocompression therapy after elective arthroplasty of the hip

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ABSTRACT: *Pneumatic compression and cryotherapy have been successfully being employed in the management of acute tissue damage. The Game Ready System (GRS) combines cyclic compression and cryotherapy. No randomised controlled trial has been performed on the effects of combined cyclic compression and cryotherapy in total hip arthroplasty (THA).*

We observed postoperative pain, morphine usage, blood loss, wound discharge, patient and medical staff satisfaction, together with the feasibility of a cryocompression machine, total hospital admission time, infection rate, deep vein thrombosis, and short-term prosthesis related problems in this context. Thirty patients, mean age 68 yrs (range 31-83 yrs) undergoing elective hip arthroplasty for end-stage osteoarthritis were included. Control patients (n = 15) received a tricot compression bandage alone, and patients studied received a tricot compression bandage plus intermittent cryocompression therapy 15 times for 30 minutes.

Haemoglobin levels on postoperative day (POD) 1 dropped 2.34 mmol/L in the control group and 1,87 mmol/L in the intervention group (p = 0,027). At POD 3 haemoglobin levels were reduced by 2,63 and 2,16 respectively (p = 0,646). A trend occurred towards lower morphine usage, shorter hospital admission time and less wound discharge in the study group. No difference was found in postoperative pain scores. One event of deep venous thrombosis occurred in the control group. Intermittent cryocompression therefore appears to reduce postoperative blood loss. A trend towards less analgesic use, shorter hospital stay, less wound discharge and less pain at 6 weeks postoperatively was also observed.

KEY WORDS: *Intermittent pneumatic compression devices, Cyrotherapy, Hip replacement arthroplasty, Postoperative blood loss, Analgesic use*

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INTRODUCTION

Total hip arthroplasty (THA) is one of the most frequently performed and cost-effective operations in orthopedic surgery (1). The average admissio lasts 5 days and overall infection rates range from less than 1 to 3% (2-4). Postoperative pain, wound discharge, haematoma and venous thrombosis can prolong hospital time and delay mobilisation. Postoperative pain is a common problem (5-7), and increases the risk of deep venous thrombosis (DVT) and prolonging hospital stay. The incidence of DVT after THA ranges from 1% to 7%, and early post-operative mobilisation is thought to reduce the risk (8, 9).

Cryotherapy and intermittent pneumatic compression (IPC) can minimise postoperative pain, blood loss, haematoma formation and wound discharge, and improve local blood circulation thus reducing the risk of DVT (10-14). Cryotherapy has been employed for decades in the management of acute soft tissue injury, and its effectiveness in preventing swelling as well as exerting analgesic effects is well recognised (12-17).

Fig. 1 - *Game Ready System.*

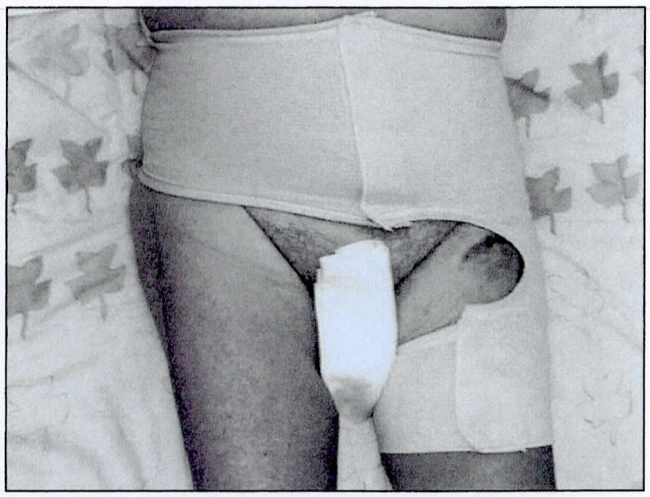

Fig. 2 - *Tricot bandage.*

Hospital admission time can be shortened by using cryotherapy after THA (18), and because of its feasibility and cost-effectiveness standard use has been advocated (19, 20). To our knowledge, no study has been performed in which cyclic cryotherapy and compression therapy have been combined. The Game Ready System® (GRS) Hip/Groin- wrap (Almeda/US, Coolsystems inc.) combines these modalities (Fig. 1), in addition to a standard tricot compression bandage (Fig. 2). We report a prospective, randomised, pilot study on the effect of intermittent cryocompression therapy following elective THA. Primary outcomes measures were numeric rating scale (NRS) pain scores, analgesic use and wound discharge. In addition, the feasibility of the system was assessed together with patient satisfaction.

PATIENTS AND METHODS

Patients

This pilot study was evaluated and approved by our ethical board committee (DOI 20-09-2010, METC number: 586.10). Between November 2010 and May 2011, all eligible patients undergoing elective THA for end-stage osteoarthritis were asked to participate. Written informed consent was obtained prior to treatment and randomisation. Patients were excluded if their preoperative weight <60 kg, perioperative blood loss >500 mL, blood transfusion was needed during admission, preoperative use of erythropoietin was employed, preoperative osteosynthesis materials were 'in situ' in the operated leg, their Amarican Society Of Anaesthesiologists (ASA) score was 3 or 4, they had cryoglobulinaemia, decompensated hypertonia, morphine allergy, angiopathy in the operated leg, a history of deep vein thrombosis, or if they underwent general anesthesia.
Low weight was considered a contraindication due to hospital policy. Blood loss >500 ml can induce vasoconstriction, and combined with cryocompression this can induce ischaemia of the distal extremity. Blood transfusion can confound outcome variables (haemoglobin and wound discharge) through an associated coagulopathy.
The use of erythropoietin can confound the postoperative estimation of haemoglobin.
Patients were randomised into two groups, (GRS-intervention and control), 15 patients in each. Randomisation took place on the day of operation prior to surgery with the use of sealed opaque envelopes. Patient baseline characteristics are provided in Table I.

Materials

Total hip arthroplasty was performed using an uncemented Zweymüller prosthesis via a transgluteal approach. All

wounds were closed with staples. All patients received a urinary catheter. After surgery blood loss was assessed and the patient was admitted to the orthopedic ward.

Regional anaesthesia consisted of 100 - 150 mcg morphine administered intradurally. The postoperative analgesic protocol consisted of standard acetaminophen 1000 mg 4 times daily, meloxicam 15 mg once daily and (on request) morphine retard 15 mg twice and morphine solution 2 mg/mL 10 mL six times daily.

After surgery patients were equipped with a patient controlled analgesia (PCA) pump for 2 days, containing 100 mg morphine and 2.5 mg droperidol in a 100 mL saline solution administered intravenously. Pump settings allowed a bolus infusion of 2 mL, lockout-time of 10 minutes, and maximum administration of 24 mg/4 hrs.

Postoperatively the 15 control patients received an absorbing bandage together with a tricot compression bandage. The intervention group received the same bandage as the control group and GRS. The Game Ready System® Hip/Groin-wrap was applied over the tricot bandage. Each treatment cycle consisted of 30 minutes of cryotherapy and cyclic compression therapy simultaneously. The minimum non-GRS-treatment interval was 4 hours. The degree of pressure could be adjusted to low (15 mmHg), medium (50 mmHg) or high (75 mmHg). The degree of cooling could be adjusted from 12°C to 0°C. The standard setting used in the study was 0°C, but if this was unacceptable to the patient the temperature or pressure was adjusted accordingly. All patients in the intervention group received the same GRS-treatment schedule: the day of surgery twice on low pressure, first postoperative day medium pressure 4 times, the second postoperative day medium pressure 4 times, third postoperative day high pressure 4 times, the fourth and final treatment day once at high pressure.

Given the non-treatment interval, a normal 4 times treatment cycle consisted of: 8:00u, 12:00u, 16:30u and 21:30u.

TABLE I - BASELINE CHARACTERISTICS

	Cryocompression	Controls
Number of cases	15	15
Age (yrs)	66 (47-82)	68 (31-83)
Sex (M/F)	8/7	4/11
ASA-class[1]	1.67 (1-2)	1.87 (1-3)
BMI[2]	26 (19-33)	27 (19-36)
NRS preoperative	1 (0-2)	1,4 (0-3)

All displayed results were not statistically significant.
Values are shown as mean (range).
[1] American Society of Anesthesiologist classification.
[2] Body mass index (kg/m²).

Data collection

All patients underwent a preoperative assessment including registration of preoperative age, ASA-classification, BMI, Harris hip score, NRS, medication use, blood pressure, heart rate, ear temperature and co-morbidities. A preoperative blood sample was taken from which haemoglobin, haematocrit, and mean corpuscular volume (MCV) were measured. Each treatment cycle GRS settings, NRS, ear temperature, blood pressure, heart rate, and use of medication were recorded before and after treatment, and in control patients recordings were performed once.

Haemoglobin, haematocrit and MCV were measured on day 1 and day 3 postoperatively. The postoperative haemoglobin concentrations were subtracted from the preoperative concentrations and the concentrations on day 3 were subtracted from day 1 concentrations. The dressing was inspected daily and discharge through was recorded (yes or no), and 2 days after surgery the wound was inspected. Urinary catheters were removed and patients commenced physiotherapy on the first postoperative day.

On the second postoperative day total morphine usage through the PCA pump was recorded and the pump was discontinued. All orally administered morphine at the patient's request was noted. All morphine used was recalculated to oramorph. The following proportion was used: oramorph 1: oxycontin 1, 5: morphine intravenous (PCA) 3 (21).

At discharge patients were asked to fill in a standardised questionnaire about their experience with the GRS. After discharge all patients were evaluated six weeks and again 1 year postoperatively. During these assessments NRS, wound discharge, deep or superficial infection, DVT, early septic loosening of the prosthesis and use of analgesic medication were recorded.

At the end of the study medical staff were interviewed about their experience with the GRS.

All prospective data of the 30 patients were collected using the SPSS program for statistics. (PASW Statistics 18, release 18.0.0 30 July 2009).

RESULTS

Patients

Of the 30 randomised patients, 4 did not receive the (complete) treatment. One patient in the control group wanted to be allocated to the GRS group, 2 patients in the intervention group had excessive perioperative blood loss, which necessitated exclusion and 1 patient in the intervention group GRS use was discontinued because of discomfort due to inability to urinate. There were no differences between the two groups regarding baseline characteristics (Tab. I). No difference in regard to perioperative blood loss was found (Tab. II).

GRS settings

On POD 1 about half of the patients had their pressure setting reduced. Thereafter 2 patients per day (on average) had their pressure reduced, and cooling was incidentally reduced.

Haemoglobin

When compared at POD 1, study group patients had a 0.55 mmol/L (statistically significant) smaller decline in haemoglobin level. At POD 3 this advantage in haemoglobin levels persisted (0.47 mmol/L smaller decline in study group patients) (Tab. II).

Morphine usage

When pooled together total oramorph usage in the control group was 100 mg compared to 84.7 mg in the intervention group (Tab. II).

Wound discharge

All 'yes' or 'no' outcomes of wound discharge were pooled together from the day of surgery untill POD 4. Analysis through Mann-Whitney-U test showed lower discharge rates in the intervention group (Tab. II).

Total admission time

The mean total hospital stay in the intervention group was 4,75 compared to 5,0 in the control group (not significant) (Tab. II). The relatively large SD originating from the control group was attributed to the 10-day hospital stay of 1 patient in contrast to the average 5-day stay. There were no differences relating to reinsertion of the urinary catheter or earlier physiotherapy between the 2 groups.

Questionnaires

When questionnaires were analysed patients were generally positive about cryocompression treatment. Pain experienced was less and mobilisation was faster. A number of patients had their temperature setting adjusted to a less

TABLE II - RESULTS OF OUTCOME VARIABLES

	Cryocompression (n = 12)	Control (n = 14)	Significance	Test
Blood loss peroperative (mL)	280 (63)	256 (129)	0.616	Levene
Haemoglobin OK+1 – preop	-1.79 (0.73)	-2.34 (0.39)	0.027	Levene
Haemoglobin OK+3 – preop	-2.16 (1.0)	-2.63 (0.49)	0.167	Levene
Haemoglobin OK+3 - OK+1	-0.38 (0.53)	-0.29 (0.36)	0.646	Levene
Wound discharge	7.13	12.09	0.053	Mann-Whitney
Total oramorph usage	84.7 (43.6)	100 (73.5)	0.593	Levene
Days of leakage	1.83 (2.34)	2.92 (3.23)	0.349	Levene
Total admittance time (days)	4.75 (0.75)	5.00 (1.63)	0.633	Levene

Values are shown as mean (SD) unless otherwise specified.
* Harris hip score.

cold setting, and high pressure was considered to be more comfortable. When asked, they would recommend cryocompression to other patients (Tab. III).
Medical staff were positive about GRS use. Appliance of the GR-wrap was generally easy, except on the day of surgery when patients' legs were still partially sedated, and on the first POD because of postoperative pain. Some difficulty occurred with the GRS in obtaining enough ice-cubes, especially when multiple patients were treated simultaneously.

Complications

At 6 weeks follow-up 1 patient from the control-group had developed deep vein thrombosis despite prophylactic treatment. No infections, use of antibiotics or early septic loosening had occurred at 6-week follow-up. There were no deaths or other adverse events in the intervention or control group.

DISCUSSION

Our study has demonstrated a lesser decline in postoperative blood loss in patients using cryocompression. In 2005 Johansson et al used a pneumatic compression bandage in 51 patients; the 54 control patients were given a wound drain. They found that the necessity for transfusion was the same, but the number of transfused units and wound discharge were significantly less in the compression group (13). Hörnberg et al in 2002 found that patients who were given a standard dressing over a compression dressing required significantly more blood transfusions (22). Fujisawa et al encountered a significant reduction in leg circumference when calf-thigh IPC was applied compared to plantar IPC after THA reflecting reduced wound oedema and blood loss (11). Our findings similarly suggest a trend towards less wound discharge in the cryocompression group.
Liu et al (1999) observed that compression caused shear stress of the vascular endothelium and therefore vasodila-

TABLE III - PATIENT QUESTIONNAIRE GAME READY EXPERIENCE

		Average score (n = 17)
1	I experienced the use of GRS as pleasant	0.54
2	I had less pain during use of GRS	0.67
3	I had the temperature adjusted (Y/N)	10% Yes
4	I liked the coldest setting best	-0.11
5	I had the pressure setting adjusted (Y/N)	45% Yes
6	I liked the highest pressure setting best	0.1
7	I applied the GRS-wrap myself (Y/N)	100% No
8	Applying the GRS-wrap was easy to perform	0.56
9	I kept the wrap on, even between treatment	-1.1
10	I was treated on time	0.9
11	Nurses had to come by often because of GRS	-1.2
12	I had little discomfort from GRS treatment	0.81
13	I think GRS is a good treatment	0.9
14	I do not regret use of GRS	1.2
15	I think I recovered faster because of GRS	0.7
16	I would recommend GRS to other patients	0.9
17	I would have like to be treated more and longer with GRS	-0.6

tation, resulting in reduced swelling (10).
We did not measure leg circumference, but the reduced decline of haemoglobin levels indicated a reduced peripheral leakage of blood and oedema fluid.
Reduction in leg swelling and shear stress induced vasodilatation prevent haematoma and stasis, both of which are risk factors for infection.
As well as reducing postoperative leg swelling, pneumatic compression also reduces thrombogenesis in the early postoperative period (11, 23, 24). Currently, wound drains are widely employed to minimise wound discharge, infection and haematoma, but such benefits have never been statistically proven (25-29). A recent systematic review showed no significant difference in the incidence of wound complications with or without drains, but the necessity for transfusion was higher in when drains are used (30).
A trend towards lower morphine usage was observed in our study, but statistical significance was not achieved, although others have demonstrated a significant difference in opiate use (12), and analgesic requirements and pain scores (19, 31). The lesser effect of cryotherapy after THA compared to knee arthroplasty may result from the inability of the therapy the reach deeper layers so effectively (32).
Although patients have been reported to start mobilisation faster, this was not seen in our study, probably due to our protocol, in which intervention patients and controls alike received physiotherapy on the first postoperative day and were discharged on POD 4.
Two adverse events occurred; deep vein thrombosis in a control patient and inability to urinate in one intervention patient. The cryocompression bandage partially covers the pubic area thus this adverse event can be a side effect of cryocompression treatment. After this event, we covered the pubic area with an extra towel before applying the GRS.
Our pilot study conclusions are hampered by a small sample size. However the advantage of a cryocompression in postoperative blood loss reduction appears to be clear.
In respect to wound discharge scoring a significant inter-observer bias may have occurred, because the ward nurse or doctor who assessed the issue changed from day to day.
Supplying the GRS with sufficient ice-cubes was difficult at the start because of insufficient capacity of the ice-cube machines. The manufacturer supplied an additional machine and a refrigerator for storage capabilities, and this provided sufficient capacity for multiple treatments simultaneously.
During the evening shift ward nurses found it difficult to apply the GRS in time (or at all) because of limited personnel. To overcome this the treatment cycles might be adjusted to 8:00 hrs, 12:00 hrs, 16:00 hrs, and 20:00 hrs.
Patients were pleased with the cryocompression bandage, and reported it to enhance comfort and reduce wound pain (Tab. III), but as they were treated on the same ward as the control patients bias cannot be ruled out.
With a reduction in blood loss created by cryocompression blood transfusion can be averted in the acute postoperative phase of THA. There may also be lower postoperative morphine consumption. Cryocompression reduces stasis and haematoma formation, and may therefore reduce the risk of infection.
However, our sample size was too small to demonstrate advantages in wound discharge rates, hospital admission time and infection rates. A larger trial may help to address these matters.

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