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Effectiveness of Hyperbaric Oxygen Therapy in Treatment of Well Leg Compartment Syndrome Post Urologic Surgeries

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Introduction

Urologic surgeries concerns the surgical treatment disorders that affect urologic pelvic structures as cancer of the prostate, adrenal glands, bladder, kidneys, ureters, testicles, and penis[1].

Compartment syndrome is a condition in which increased pressure within a limited space which compromises the circulation and function of the tissues within that space. There are numerous causes of acute compartment syndrome, including fractures, soft tissue trauma, and prolonged limb compression following drug overdose, burns, and reperfusion of ischemic tissue, however the most common precipitating factor is traumatic injury [2].

Well leg compartment syndrome (WLCS)is being increasingly recognized after urological, gynaecologic, orthopedic or general surgical procedures with the common denominator of patient positioning in the lithotomy or hemilithotomy position[3].The lithotomy position is commonly used to access the pelvis and perineum during urological, colorectal, and gynecologicalsurgery. Lower limb compartment syndrome is caused by abnormal increases in intracompartmental pressures within a non-expansile fascial space and has been recognized after prolonged elevation of the lower limbs during surgical procedures in the lithotomy position. Commonly compartment syndrome involves ischaemia, hypoxia and oedema[4]. If prolonged urological procedure is necessary patient should be monitored post operatively for early and prompt treatment of this complication. Early diagnosis and proper treatment is the main-stay of the treatment in cases of acute compartment syndrome following unavoidable prolonged urological procedures in lithotomy position[5].

Hyperbaric oxygenation (HBO) therapy is defined as a treatment in which the patient breathes 100% oxygen at pressures greater than atmospheric; this causes the P02 to increase in proportion to the increase in ambient pressure. True HBO therapy only refers to the systemic delivery of oxygen via the lungs and is not related to "topical oxygen therapy, in which only a specific body part is subjected to locally delivered oxygen under pressure[6].

A further form of conservative treatment for compartment syndrome is hyperbaric oxygenation. This specifically reduces oedema and floods the tissues with oxygen dissolved in the extracellular fluid. This oxygen is available to the compromised cells without the energy expenditure otherwise required for its transfer from haemoglobin. In a series of patients with compartment syndrome who were treated with hyperbaric oxygen, that none progressed and none required a fasciotomy[7].

In traumatized hypoxic tissue such as in compartment syndrome, HBO not only tackles symptomatic hypoxia by delivering more oxygen, but also addresses the cause of hypoxia by reducing the volume of the edematous tissue. The cycle of edema-hypoxia-vasodilation may thus be interrupted and potentially reversed [8].

As far as the literature review is concerned, there is no enough available information to describe the changes of hyperbaric oxygen therapy on lower limb compartment syndrome after urological pelvic surgeries, therefore, this research aimed to investigate the effect of hyperbaric oxygen therapy on lower limb compartment syndrome after urological pelvic surgery, which may prove to be a promising intervention helping to decrease edema, improve blood flow to lower limb, decrease subsequent ischemia and decrease risks of post operative complications following urological surgeries.

Subjects, Material and Methods:

1-Subjects:

Forty patients of both sexes (16 males and 24 females) who had compartment syndrome following urological pelvic surgeries were selected and recruited randomly from Nasser Institute Hospital. Patient's ages ranged from 20-40 years. These patients will be divided into two equal groups in number: Group A (Hyperbaric oxygen therapy group):Twenty patients (7 males and 13 females) received hyperbaric oxygen therapyin addition to traditional physical therapy program in form of calf stretching, soft tissue mobilization and massage.Group B (Control group): Twenty patients received only traditional physical therapy program in form of calf stretching, soft tissue mobilization and massage.

2- Material and Methods:

Physical and Clinical Examination:

Each subject was examined medically in order to exclude any abnormal medical problems. History was taken in previously prepared questionnaire to collect information about, name, age and determination about any functional, social, psychological problems. The purpose of evaluation procedures were explained in steps for each patient in each group.

2.1. Measuring equipment and tools:

2.1. (a) Arterial pressure index by duplex ultrasonography:

A subspecialty within ultrasonography helps determine multiple factors within the circulatory system. It can evaluate central (abdominal) and peripheral arteries and veins; it helps determine the amount of vascular stenosis (narrowing) or occlusion (complete blockage) within an artery[9]**.** The patient was placed supine and a blood pressure cuff is placed about the ankle of the injured lower extremity. The cuff was inflated and then slowly deflated, and the Doppler probe was used to determine the systolic pressure in the lower extremity. The probe was placed over the anteriortibial artery or dorsalispedis. The systolic pressure in the injured extremity was then compared to the systolic pressure of an uninjured upper- or lower-extremity limb (arterial pressure index=Doppler systolic arterial pressure in injured limb/Doppler systolic arterial pressure in uninjured limb). A Doppler ultrasound blood flow detector, commonly called Doppler Wand or Doppler probe, and a sphygmomanometer (blood pressure cuff) were usually needed. The blood pressure cuff was inflated proximal to the artery in question. Measured by the Doppler wand, the inflation continues until the pulse in the artery ceases. The blood pressure cuff was then slowly deflated. When the artery's pulse was re-detected through the Doppler probe the pressure in the cuff at that moment indicates the systolic pressure of that artery. The higher systolic reading of the left and right arm brachial artery is generally used in the assessment. The pressures in each foot's anterior tibial artery and dorsalispedis artery are measured with the higher of the two values used as the ABI for that leg.

$$ABPI_{Leg} = \frac{P_{Leg}}{P_{Arm}}$$

Where P_{Leg} is the systolic blood pressure of dorsalispedis or anterior tibial arteries.

And P_{Arm} is the highest of the left and right arm brachial systolic blood pressure.

2.1. (b) Measurements of circumferential lower limb edema by plastic tape measure centimeter:

Patient was asked to stand or sit with both feet firmly on the ground.On the medial aspect of the leg measure with a ruler and record the distance from the floor to 2cm above the middle of the medialmalleolus on both legs which was the starting point. Patient seated on a chair with bottom as close to the edge as possible, or seat on a couch with the leg straight.Lie a ruler along the medial aspect of the leg and mark the limb at 4cmintervals from the starting point to 2cm below. With the limb in a relaxed position, thetherapist measured the circumference at each mark, placing the top edge of the tape measure just below the mark.

2.1. (c) Measurement of pain intensity by Visual analog scale(VAS):

The pain VAS is a unidimensional measure of pain intensity which has been widely used in diverse adult populations, The pain VAS is a continuous scale comprised of a horizontal (HVAS) or vertical (VVAS) line, usually 10 centimeters (100 mm) in length, For pain intensity, the scale is most commonly anchored by no pain (score of 0) and pain as bad as it could be or worst imaginable pain (score of 10)[10]**.** While the patient sit comfortly he/she was instructed to point out the degree of pain on a visual analogue scale in a form of a horizontal 100mm line numbered from 0 to 10 in an interval of 10 mm drawn on a paperwhere he/she marks on the degree of pain at which 0 is the point of no pain and 10 is the point of severe pain both before and after treatment.The visual analog scale (VAS) is a tool widely used to measure pain. A patient is asked to indicate his/her perceived pain intensity (most commonly) along a 100 mm horizontal line, and this rating is then measured from the left edge (5VAS score).

2.2Therapeutic equipment:

In this phase, the treatment procedures were conducted by the following equipment and tool:

2.2.(1) Hyperbaric oxygen therapy:

Hyperbaric oxygen therapy (HBOT) is defined as systemic treatment in which the entire patient is placed inside a pressurized chamber and breathes 100 % oxygen under a pressure greater than 1 atmosphere. It is used to treat certain diseases and conditions that may improve when an increased partial pressure of oxygen is present in perfused tissues[11]**.** Before starting the treatment instruct the patients to go to the bathroom, remove your underwear, nylons and socks, put on the special gown, do not smoke during the course of your treatment. Smoking reducesthe amount of oxygen the blood can carry and will reduce the effectiveness of the treatment.

B-Treatment sessions:

Treatment was delivered in a monoplace chamber, in which a single patient is accommodated in a cylinder, now generally made of acrylic material to permit patient observation.The ambient gas was compressed air, with patients breathing 100% oxygen through masks or hoods.The duration of treatment session is 60 minute.HBO treatment sessions are generally conducted at pressures of 2-2.4 ATA. In order to minimize the risk of oxygen toxicity, periods breathing 100% oxygen were separated by brief intervals of breathing air.Frequency of treatment sessions is 2 sessions daily during the following2 days and one session daily during 3 or 4 days for 4 weeks. The number of HBO treatments per patient ranged from 3 to 45; the mean is12 sessions.

Results:

1) Patient Demographic Data:

As reflected from **table (1),** Comparison of mean values of age, weight and heightin both groups (A & B) indicated that there is no significant difference inboth groups.

Table (1):Represents comparison of the age, weight and height as variables in both groups (Group A and Group B).

item	Age (years)		Weight (kg)		Height (cm)	
	(Group A)	(Group B)	(Group A)	(Group B)	(Group A)	(Group B)
Mean± SD	27.9 ± 5.66	30.5 ± 5.77	68.3 ± 10.3	67.8 ± 10.2	168.35 ± 4.08	165.3 ± 6.78
T-value	1.44		0.17		1.72	
P-value	0.159		0.866		0.095	
Level of significance	N.S		N.S		N.S	

± S.D: Standard Deviation.**P-value:** Probability Level.**N.S.:** Non Significant.

2) Results of the Visual Analogue Scale (VAS):

As reflected from **table (2),** there was statistical significant decrease in the Visual analog scale (VAS) mean value after four weeks of treatment application in both groups(A& B) when compared with the corresponding mean value before treatment application (pre-treatment) (p=0.001).

Table (2): Comparison between pre and post- treatment application values of Visual analog scale (VAS) in both groups (A& B).

items	Visual analog scale (VAS) for study group (A)		Visual analog scale (VAS) for control group (B)	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Mean± SD	6.6± 0.99	3.05± 1.19	6.45± 1.5	4.15± 1.04
T-value	16.81		21.88	
P-value	0.001		0.001	
% of improvement	50 %		42.85 %	
Level of significance	S		S	

± S.D: Standard Deviation.**P-value:** Probability Level.**S:** Significant.

Comparison of Visual analog scale (VAS) between the two groups (A and B):

As shown in **table (3),** when comparing the two groups (A and B) before treatmentthere are no significant improvement (p> 0.05).While comparing the two groups after four weeks of treatmentindicated a significant improvement in favor of the study group (A) and the percentage of improvement was 33.33 %**.**

Table (3): Comparing between pre and post treatment mean values of Visual analog scale (VAS) among the two groups (A and B).

Items	Visual analog scale (VAS)			
	Pre treatment (Group A)	Pre treatment (Group B)	Post treatment (Group A)	Post treatment (Group A)
Means±SD	6.6± 0.99	6.45± 1.5	3.05± 1.19	4.15± 1.04
T-Value	0.46		3.11	
P-Value	0.65		0.004	
Level of significance	NS		S	

± S.D: Standard Deviation.**P-value:** Probability Level.**S:** Significant.**N.S.:** Non Significant.

3) Results of circumferential lower limb edema:

At 2cm from medial malleolus:

As reflected from **table (4)**, there was statistical significant decrease in the circumferential lower limb edema at 2cm from medial malleolus after four weeks of treatment application in both groups when compared with the corresponding mean value before treatment application (pre-treatment) (p=0.001).

Table (4): Comparison between pre and post- treatment application values of circumferential lower limb edema at 2cm from medial malleolus in both groups.

items	Circumferential lower limb edema at 2cm from medial malleolus for group (A)		Circumferential lower limb edema at 2cm from medial malleolus for group (B)	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Mean ± SD	32.8± 1.6	27.52± 1.65	32.55± 1.9	30.9± 2.24
% of improvement	16.07%		10.13%	
T-value	28.81		6.49	
P-value	0.001		0.001	
Level of significance	S		S	

± S.D: Standard Deviation.**P-value:** Probability Level.**S:** Significant.

At 4cm from medial malleolus:

As reflected from **table (5)**, there was statistical significant decrease in the circumferential lower limb edema at 4cm from medial malleolus after four weeks of treatment application in both groups when compared with the corresponding mean value before treatment application (pre-treatment) (p=0.001).

Table (5): Comparison between pre and post- treatment application values of circumferential lower limb edema at 4cm from medial malleolus in both groups.

items	circumferential lower limb edema at 4cm from medial malleolusfor group (A)		circumferential lower limb edema at 4cm from medial malleolusfor group (B)	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Mean ± SD	23.2± 2.33	16.73± 1.74	22.35± 1.87	20.57± 1.78
% of improvement	27.88%		15.83%	
T-value	17.72		6	
P-value	0.001		0.001	
Level of significance	S		S	

± S.D: Standard Deviation.**P-value:** Probability Level.**S:** Significant.

Comparison of circumferential lower limb edemabetween both Groups (A and B):

Table (6) shows that there was a non-significant difference in the mean values of circumferential lower limb edema at 2cm and 4cm from medial malleolus (pre-treatment values) between both groups (A and B) groups (p= 0.657) and (p= 0.212) respectively.

It is clear from **table (6),** the circumferential lower limb edema at 2cm and 4cm from medial malleolus after four weeks of treatment application (post) of study group (group A) has a significant improvement when compared with control group (group B) (p=0.001).

Table (6): Represents comparison of the mean values of circumferential lower limb edema at 2cm and 4cm from medial malleolus in (pre- treatment) and (post- treatment)between both groups (A and B groups).

item	circumferential lower limb edema at 2cm from medial malleolus (pre- treatment)		circumferential lower limb edema at 2cm from medial malleolus (post- treatment)		circumferential lower limb edema at 4cm from medial malleolus (pre- treatment)		circumferential lower limb edema at 4cm from medial malleolus (post- treatment)	
	(Group A)	(Group B)	(Group A)	(Group B)	(Group A)	(Group B)	(Group A)	(Group B)
Mean ± SD	32.8 ±1.6	32.55 ±1.9	27.52 ±1.7	30.9 ±2.3	23.2± 2.3	22.35± 1.9	16.73 ± 1.7	20.57± 1.8
T-value	0.45		5.42		1.27		6.9	
P-value	0.657		0.001		0.212		0.001	
Level of significance	N.S		S		N.S		S	

± S.D: Standard Deviation.**P-value:** Probability Level.**S:** Significant.**N.S.:** Non Significant.

***Results of Ankle brachial pressure index:**

As reflected from **table (7),** there was statistical significant increase in the Ankle brachial pressure index after four weeks of treatment application in both groups when compared with the corresponding mean value before treatment application (pre-treatment) (p=0.001).

Table (7): Comparison between pre and post- treatment application values of Ankle brachial pressure index in both groups.

items	Ankle brachial pressure index for group (A)		Ankle brachial pressure index for group (B)	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Mean ± SD	0.88± 0.06	1.2± 0.1	0.86± 0.06	0.96± 0.09
% of improvement	37.5%		10%	
T-value	15.43		5.83	
P-value	0.001		0.001	
Level of significance	S		S	

± S.D: Standard Deviation.**P-value:** Probability Level.**S:** Significant.

Comparison ofAnkle brachial pressure index between both Groups (A and B):

Table (8) shows that there was a non-significant difference in the mean values of Ankle brachial pressure index (pre-treatment) between both groups (A and B) groups (p= 0.338).

It is clear from **table (8),** the Ankle brachial pressure index after four weeks of treatment application (post) of study group (group A) has a significant increase when compared with control group (group B) (p=0.001).

Table (8): Represents comparison of the mean values of Ankle brachial pressure index in (pre-treatment) and (post- treatment) between both groups (A and B groups).

item	Ankle brachial pressure index (pre- treatment)		Ankle brachial pressure index (post- treatment)	
	(Group A)	(Group B)	(Group A)	(Group B)
Mean± SD	0.88 ± 0.06	086 ± 0.06	1.2 ± 0.1	0.96 ± 0.09
T-value	0.97		7.99	
P-value	0.338		0.001	
Level of significance	N.S		S	

± S.D: Standard Deviation.**P-value:** Probability Level.**S:** Significant.**N.S.:** Non Significant.

Discussion:

While individual studies of HBO in the treatment of crush injury and compartment syndromes show promising results, the quality of this evidence is very limited[12]**.**

This result comes in agreement with **Mathew et al.,** [14]who studied effect of HBO therapy on a football player developed an acute paraspinal compartment syndrome after a weight-lifting strain, and Treatment consisted of forced diuresis and six sessions in the hyperbaric oxygen chamber and reported that After the first session, the Creatine kinase (CK) had decreased, and after the second session the pain was much better controlled. The patient was able to mobilize with only moderate discomfort after the third session. He underwent a total of six sessions, and was discharged after one week. Over the next four months the patient was periodically followed. Within this time period, the CK was completely normalized and the back pain continued to progressively improve. He was able to resume physical activities, and complained only of pain upon exertion which slowly improved during this period.

This result comes in agreement with [15]who studied effect of HBO on a case study subjected to chronic iliac artery stenosis and distal gangrene first right toe and gangrene of second right toe involving more than half of the digit, Since the patient was likely to benefit from HBOT, he was taken up for 30 sittings of HBOT (40 min at 2.5 ATA with 2 ft/min ascent and descent rates) and repored that after 10 sessions of HBOT there was a marked improvement in the form of reduced swelling over dorsum of foot and improvement in colour of skin over foot and second toe. The patient also had marked relief from local pain and after next ten sessions, the wound below the nail of great toe on plantar aspect marginalised and there was a marked decrement in size of the wound. Also, the colour of the skin continued to improve. The pain had reduced markedly by this time. After 30 sessions, there was a clear demarcation of the affected area in the right second toe and a reduction in size of the wound was observed. The peripheral pulses which were absent at the start of the session were palpable now and there was complete relief from pain.

This results of the study comes in agreement with [16]who studied the effect of hyperbaric oxygen in crush injuries and skeletal muscle-compartment syndromes and reported that for the impending stage of the Skeletal muscle-compartment syndrome (SMCS), HBO2 treatments should be given twice a day for 24 to 36 hours, the time that the self-perpetuating edema-ischemia cycle would be expected to end. Symptoms and signs of pain reduction, absence of neurological abnormalities, and less tautness in the compartment should be used in deciding to stop HBO2. For residual complications after fasciotomy has been performed for an established compartment syndrome, HBO2 should be given twice a day for a seven- to 10- day period or when the problems have stabilized enough that no benefit is being realized from HBO2. Treatment durations and pressures are the same for crush injuries: that is, 90- to 120-minute durations at 2.0 to 2.4 atm abs.

This results of the study comes in agreement with[17] in a double-blind placebo controlled RCT on 36 patients found a significant increase in complete wound healing and reduction in repetitive surgery (including amputation), concluding that HBO is a useful adjunct in the management of severe (grade III) crush injuries of the limbs in patients more than 40 years old.

This results of the study comes in agreement with [18]reported a case of compartment syndrome associated with an acute exertional injury, in which after surgical decompression, HBOT reduced the oedema and improved tissue viability.

The results of this study comes in disagreement with [19] who studied relationship between ulcer healing after hyperbaric oxygentherapy and transcutaneous oximetry, toe blood pressureand ankle–brachial index in patients with diabetesand chronic foot ulcers and reported that in the HBOT group baselinetranscutaneous oximetrywere significantly lowerfor patients whose ulcer did not heal as compared withthose whose ulcers healed. A significantly increasedhealing frequency was seen with increasing baselinetranscutaneous oximetrylevels in the HBOT group. No statistically significant relation between thelevel of TBP or ABI and healing frequency was seen.

Conclusion:

Hyperbaric oxygen therapy was useful for reducing rate of complication of lower limb compartment syndrome after urological pelvic surgery. AlsoDuplex ultrasonography is extremely effective, valid and inexpensive tool in assessment of edema.

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