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Research Article

A New Method to Decrease the Occurrence of Embolic Events during Total Hip Replacement

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Abstract

Aim: The goal of this study is to assess the efficacy of a modified surgical technique, designed to limit the increase in intramedullary pressure during insertion of the prosthesis and to reduce intra- operative embolic events.

Patients and Methods: Forty patients treated with total hip replacement in Tanta university hospitals divided into 2 groups (group 1) treated with conventional cementing technique and (group 2) treated with a modified cementing technique with a cannula inserted into the intertrochanteric region of the femur to decrease the intramedullary pressure to avoid the increase of the intramedullary pressure after application of the cement and insertion of the stem.

Results: There was a significant difference between the incidence of embolism and increased pulmonary artery pressure (detected by trans-thoracic Echocardiography) between both groups of patients where the incidence of both were found to be much lower when the modified technique was used. Also the changes in the hemodynamic parameters (heart rate, blood pressure, and central venous pressure) accompanying the appearance of emboli in Echocardiography especially grades 2 and 3 embolism were found to be significant in the conventional cementing group ($p < 0.05$).

The changes in the respiratory parameters (decreased oxygen saturation, decreased arterial oxygen tension, decreased end tidal CO_2, and increased arterial CO_2) accompanying the appearance of emboli in Echocardiography especially grades 2 and 3 embolism were found to be significant in the conventional cementing group ($p < 0.05$).

Conclusion: Modified surgical technique (A vacuum drainage of the proximal femur along the linea aspera) was found to be effectively reducing the incidence of embolization during cemented hip arthroplasty.

Keywords: Total Hip Replacement; Embolic Events; Hip Arthroplasty; Intra-Operative Embolic Events.

Introduction

Severe complications may be observed in hip replacement surgery. These complications include hemodynamic and respiratory changes such as hypotension, hypoxia and rarely it can progress to cardiac arrest [1]. The toxic effect of methylmethacrylate was at one time widely considered to be the main contributor to these changes but the mechanism of methyl-methacrylate is unproven. Recently other theories have been advanced to explain these changes: embolism of fat, air and bone marrow evidenced by presence of multiple pulmonary fat embolic material in the autopsy after death, embolization by fine particles of bone (bone dust) originated from reamed bone, giving characteristic images by trans-esophageal echocardiography called (snow flurry), this theory is evidenced by pathological examination of venous emboli during total hip arthroplasty [2].

The third theory denotes release of tissue thromboplastin during acetabular and femoral reaming that activate extrinsic coagulation system resulting in decreased plasma fibrinogen concentration and increased fibrin degradation product, this activation of coagulation leads to microvascular thrombosis which accounts for increased pulmonary vascular resistance and pulmonary hypertension [3].

In human studies venous embolisation has been detected by echocardiography. During hip arthroplasty several factors determine the severity of cardiopulmonary effect: The degree of embolisation visualized by echocardiography, the compliance of the pulmonary vasculature and cardiovascular status before embolism [1].

Modifications of the operative technique are designed to minimize intramedullary hypertension thus decreasing the risk of embolism during total hip arthroplasty. These changes in surgical techniques should be considered when cement fixation is used in patients thought to be at risk for having cardiopulmonary complication during total hip arthroplasty.

Aim of the Work

The aim of this study was to assess the efficacy of a modified surgical technique, designed to limit the increase in intramedullary pressure during insertion of the prosthesis and to reduce intra-operative embolic events.

Patients and Methods

This study was carried out in the orthopedic department in Tanta university hospitals in the period between May 2004 and May 2007. Forty patients were included in this study, thirteen males and 27 females. The age ranged between 40-70 years. All patients were operated by the staff of orthopedic department in Tanta university hospitals. The main cause for operating was degenerative hip disease. Patients with rheumatoid arthritis, history of deep venous thrombosis or pulmonary embolism were excluded from this study.

- **Intra-operatively:** The patients were divided into two groups (20 patients in each group).
- **Group I:** Included the patients who received a femoral component inserted with a conventional cementing technique.
- **Group II:** Included the patients operated with a modified cementing technique using a cannula with a diameter 4-5mm positioned along the prolongation of the linea aspera into the calcaneous bone of the intertrochanteric region to avoid the increase in the intramedullary pressure and migration of fat and bone marrow into the veins of the thigh during application of the cement and insertion of the stem [4]. The canula was introduced before reaming. Also pulsatile high-volume lavage (1000 mL of Saline solution) was performed in all patients before cementing of the stem to wash the bone surface.
- **Monitoring**: Three leads electrocardiogram, non invasive measurement of blood pressure, pulse oximetric oxygen saturation and end-tidal carbon dioxide tension were used. Insertion of central venous catheter into the right internal Jugular vein of the patients and arterial cannula into the left radial artery after doing modified Allen's test was done in all patients. Arterial CO_2 tension, arterial oxygen tension, pH, oxygen saturation CVP and blood pressure were measured at defined points of the operative period (time of operative incision, 5 min after insertion of the cup, after preparation of the femur, 5 min after insertion of the stem, 5 min after relocation of the hip joint, 15 min after relocation of the hip joint, and 2 h after the end of the operation). Echocardiographic findings (recorded at the previous points of the operative period) were compared with the clinical and laboratory data.
- **Statistics:** Repeated measures analyses of variance (ANOVA test) for intergroup comparisons were performed for all of the samples used for arterial blood gas determination and for the measurement of end-tidal carbon dioxide levels. Differences were considered statistically significant with the values of $P < 0.05$. Subgroup analysis was done using ANOVA test to show the relations between the ASA grade and embolic grade to the severity of change in the hemodynamic and respiratory parameters. The least significance difference (LSD) was used to determine the significant changes in the same group.

Results

Demographic data: In this study, demographic data collected from 40 patients (13 males and 27 females) undergoing Total

Hip Arthroplasty are illustrated in table (1). Demographic characteristics were comparable in the two groups. The mean duration of the operation was shorter in Group 1 (insertion of the component with a conventional cementing technique) than Group 2 (insertion of the component with the modified cementing technique). There was no significant difference between the two groups with respect to sex, age, body weight, amount of blood loss, or associated systemic disease. A severe systemic disease (class 3 or 4, according to the criteria of the American Society of Anesthesiologists was present in six patients (30 percent) in Group 1 and in seven patients (35 percent) in Group 2.

Echocardiographic features

Embolic Events: No embolic events were observed with use of echocardiography during the operative approach to the hip, the dislocation of the femoral head, the reaming of the acetabulum, or the insertion of the cup in both groups. A significant increase in the incidence of grade 2 and 3 embolism was observed in the group 1 compared with group 2 ($p < 0.05$) after preparation of the femur, implantation of the stem, and relocation of the hip joint (Figure I, II, III, IV and Table 2). The appearance of grade 3 embolic events (masses more than 5 millimeters in diameter) after the relocation of the hip joint was probably caused by twisting of a thigh vessel, accumulation of bone.

Pulmonary artery pressure

The mean pulmonary artery pressure showed significant increase ($p < 0.05$) in the conventional cementing group patients after insertion of femoral stem and relocation of hip joint, but the change was insignificant in the patients with modified cementing technique (Table 3).

The hemodynamic and respiratory Parameters:

The clinical relevance of the echo-cardiographically diagnosed emboli was determined by recording changes of hemodynamic and respiratory parameters.

Hemodynamic parameters

- **Heart Rate:** In the conventional cementing group heart rate showed a significant increase after insertion of the stem and relocation of the hip joint ($p < 0.05$). The patients with modified cementing technique group did not show any significant changes of the heart rate (Table 4).
- **The Blood Pressure:** A significant decrease of the mean blood pressure was observed after insertion of the stem and persisted after relocation of the hip joint ($p < 0.05$) in the conventional cementing group of patients (Table 5). In the patients with modified cementing technique group, the blood pressure did not change significantly during the operation.
- **Central Venous Pressure (CVP):** CVP increased in the conventional cementing group patients after insertion of femoral stem and persisted after relocation of hip joint ($p < 0.05$), but in patients with modified cementing technique, CVP showed insignificant changes (Table 6).

Respiratory parameters

- **Oxygen Saturation (SaO_2):** The oxygen saturation decreased significantly ($p < 0.05$) after the insertion of the femoral component with use of a conventional cementing technique (Table 7). These changes persisted during and after the relocation of the hip joint. But insignificant changes in the intraoperative oxygen saturation values were observed patients belonged to in groups 2 (modified cementing technique).
- **Arterial Oxygen Tension (PaO_2):** The arterial oxygen tension (PaO_2) decreased significantly ($p < 0.05$) after the insertion of the femoral component with use of a conventional cementing technique (Table 8). These changes persisted during and after the relocation of the hip joint. Physiological baseline values were reached only at the end of the operation. Only insignificant changes in the intraoperative oxygen saturation values were observed patients belonged to in groups 2 (modified cementing technique).
- **End Tidal CO_2 ($ETCO_2$):** In Group 1, there was a significant decrease of $ETCO_2$ after insertion of the femoral component (Figure V). The difference between the mean levels of end tidal carbon dioxide before and after insertion of the femoral component with use of a conventional cementing technique was significant ($p < 0.05$). These changes persisted during and after the relocation of the hip joint. The levels of end tidal carbon dioxide showed no significant changes during the operation in all patients in groups 2.
- **Arterial CO_2 Tension ($PaCO_2$):** In Group 1, there was a significant increase of $PaCO_2$ after insertion of the femoral

component ($p < 0.05$) (Figure VI). These changes persisted during and after the relocation of the hip joint. Physiological baseline values were reached only at the end of the operation. The levels of end tidal carbon dioxide showed no significant changes during the operation in all patients in Groups 2.

- The patients with ASA class III and IV showed significant changes($p < 0.05$) in the hemodynamic and respiratory parameters (increased heart rate, central venous pressure, mean pulmonary artery pressure and arterial CO_2 tension but decreased mean blood pressure, Oxygen saturation, End-tidal CO_2, and arterial oxygen tension) while the patients with ASA class I and II showed insignificant changes. Also the patients with embolic grades 2 and 3 showed significant changes ($p < 0.05$) in the hemodynamic and respiratory parameters, while in patients with embolic grade 0 and 1 the changes were significant.
- Signs of neurological impairment and strokes did not occur in patients undergoing total hip arthroplasty in our study.

Parameter	**Group I (Conventional cementing technique) (*n* =20).**	**Group II (Modified cementing technique) (*n* =20).**
Sex (M:F)	6:14	7:13
Age (years)	65 ± 5.1	67 ± 5.7
Weight (kg)	73 ± 8	68 ± 7
Height (cm)	167 ± 5	162 ± 9
Duration of the operation (minutes)	131 ± 14	140 ± 26
Estimated blood loss (ml)	1211 ± 376	1180 ± 451
Physical status (ASA)* Grade 1 Grade 2 Grade 3 Grade 4	 7 7 5 1	 10 3 6 1

Table 1: Demographic data.

* Grade 1 = a normal healthy patient. Grade 2 = a patient with a mild systemic disease. Grade 3 = a patient with a severe systemic disease. Grade 4 = a patient with an incapacitating systemic disease.

Event	**Group 1**			**Group 2**		
	Grade 1	**Grade 2**	**Grade 3**	**Grade 1**	**Grade 2**	**Grade 3**
Preparation of femoral canal: No. of patients (percent). Duration of embolic event (secs) (mean ± SD)		 4 (20%) 5 ± 1.5	 2 (10%) 4 ± 2			
Implantation of stem: No. of patients (percent). Duration of embolic event (secs) (mean ± SD)		 8 (40%) 4 ± 1.5	 5 (25%) 6 ± 2	 5(25%) 2 ± 2.5		

5 min after relocation of hip joint: No. of patients (percent). Duration of embolic event (secs.) (mean ± SD)	4 (20%) 5 ± 3.3	5(25%) 4 ± 2.5	1 (5%) 2 ± 2	13 (65%) 3 ± 2		

Table 2: Transatrial embolic events during the operation.

Stage of the operation	Group 1 Mean ± SD	Group 2 Mean ± SD
Time of operative incision	14.2 ± 0.95	15.05 ± 1.76
5 min after insertion of the cup	15.2 ± 0.95	16.05 ± 1.66
After preparation of the femur	16.4 ± 3.7	16 ± 1.66
5 min after insertion of the stem	18.6 ± 5.08* a, b, c	16.25 ± 1.92
5 min after relocation of the hip joint	19.6 ± 5.93* a, b, c	16.75 ± 1.55
15 min after relocation of the hip joint	18.5 ± 5.04* a, b, c	16.85 ± 1.39
2 h after the end of the operation	15.2 ± 095	16.4 ± 1.54
F	4.77	0.82
P	0.000 *	0.555

Table 3: Pulmonary artery pressure (in mm Hg) in both groups.

* The difference was significant compared with the other group (p < 0.05).

a = significant with stage 1 by LSD (least significance difference).

b = significant with stage 2 by LSD (least significance difference).

c= significant with stage 3 by LSD (least significance difference).

Stage of the operation	Group 1 Mean ± SD	Group 2 Mean ± SD
Time of operative incision	76.1 ± 4.59	73.5 ± 3.6
5 min after insertion of the cup	77.95 ± 4.5	73.8 ± 2.7
After preparation of the femur	80.9 ± 11.3	74 ± 2.7
5 min after insertion of the stem	88.1 ± 19.9 * a, b, c	74.9 ± 4.5
5 min after relocation of the hip joint	88.95 ± 21.2 * a, b, c	73.4 ± 4.8
15 min after relocation of the hip joint	91.2 ± 23 * a, b, c	73.3 ± 4.9
2 h after the end of the operation	73.7 ± 5.29	74 ± 2.8
F	4.57	0.13
P	0.000 *	0.992

Table 4: The heart rate (beats / min.) in both groups during the different stages of the operation.

* The difference was significant compared with the other group (p < 0.05).

a = significant with stage 1 by LSD (least significance difference).

b = significant with stage 2 by LSD (least significance difference).

c= significant with stage 3 by LSD (least significance difference).

Stage of the operation	Group 1 Mean ± SD	Group 2 Mean ± SD
Time of operative incision	91.41 ± 7.85	90.51 ± 7.3
5 min after insertion of the cup	90.44 ± 5.39	89.95 ± 6.68
After preparation of the femur	86.86 ± 10.44	88.6 ± 6.56
5 min after insertion of the stem	83.17 ± 11.12* a, b, c	85.01 ± 6.97
5 min after relocation of the hip joint	83.21 ± 9.79 * a, b, c	89.03 ± 7.70
15 min after relocation of the hip joint	83.41 ± 9.87 * a, b, c	88.20 ± 5.45
2 h after the end of the operation	91.67 ± 7.96	91.37 ± 7.60
F	3.85	1.76
P	0.001*	0.1

Table 5: The mean blood pressure in both groups during the different stages of the operation.

* The difference was significant compared with the other group ($p < 0.05$).

a = significant with stage 1 by LSD (least significance difference).

b = significant with stage 2 by LSD (least significance difference).

c= significant with stage 3 by LSD (least significance difference).

Stage of the operation	Group 1 Mean ± SD	Group 2 Mean ± SD
Time of operative incision:	11 ± 0.95	12.8 ± 1.2
5 min after insertion of the cup	11.8 ± 0.95	13 ± 0.9
After preparation of the femur	12 ± 1.66	13.4 ± 0.9
5 min after insertion of the stem	14.6 ± 3.55 * a, b, c	13.9 ± 1.2
5 min after relocation of the hip joint	15.3 ± 4.52 * a, b, c	14 ± 1.3
15 min after relocation of the hip joint	16 ± 4.3 * a, b, c	13 ± 1.4
2 h after the end of the operation	11.8 ± 0.95	12.7 ± 1.2
F	8.50	1.34
P	0.000 *	0.125

Table 6: The central venous pressure (measured in cm H_2O) in both groups during the different stages of the operation.

* The difference was significant compared with the other group ($p < 0.05$).

a = significant with stage 1 by LSD (least significance difference).

b = significant with stage 2 by LSD (least significance difference).

c= significant with stage 3 by LSD (least significance difference).

Stage of the operation	Group 1 Mean ± SD	Group 2 Mean ± SD
Time of operative incision	98.05 ± 0.94	97.9 ± 0.79
5 min after insertion of the cup	99.05 ± 0.94	98.25 ± 0.85
After preparation of the femur	97.75 ± 1.83	98.85 ± 0.81
5 min after insertion of the stem	95.15 ± 5 * [a, b, c]	97.35 ± 1.23
5 min after relocation of the hip joint	93.05 ± 5.52* [a, b, c]	98.05 ± 1.32
15 min after relocation of the hip joint	92.4 ± 5.8 * [a, b, c]	97.95 ± 1.05
2 h after the end of the operation	99.95 ± .94	99.15 ± 0.88
F	12.54	1.75
P	0.000 *	0.115

Table 7: The oxygen saturation (in %) in both groups during the different stages of the operation.

* The difference was significant compared with the other group ($p < 0.05$).

a = significant with stage 1 by LSD (least significance difference).

b = significant with stage 2 by LSD (least significance difference).

c= significant with stage 3 by LSD (least significance difference).

Stage of the operation	Group 1 Mean ± SD	Group 2 Mean ± SD
Time of operative incision	107.7 ± 8.08	115 ± 8.1
5 min after insertion of the cup	106.35 ± 7.88	113 ± 7.9
After preparation of the femur	104.65 ± 8.58	111 ± 8.6
5 min after insertion of the stem	96.05 ± 9.54 * [a, b, c]	112 ± 9.5
5 min after relocation of the hip joint	98.75 ± 9.80 * [a, b, c]	112.7 ± 8.5
15 min after relocation of the hip joint	97.6 ± 11.11 * [a, b, c]	114 ± 8.3
2 h after the end of the operation	107.7 ± 8.08	114.6 ± 7.5
F	6.19	1.75
P	0.000 *	0.115

Table 8: The arterial O_2 tension (in mm Hg) in both groups during the different stages of the operation.

* The difference was significant compared with the other group ($p < 0.05$).

a = significant with stage 1 by LSD (least significance difference).

b = significant with stage 2 by LSD (least significance difference).

c= significant with stage 3 by LSD (least significance difference).

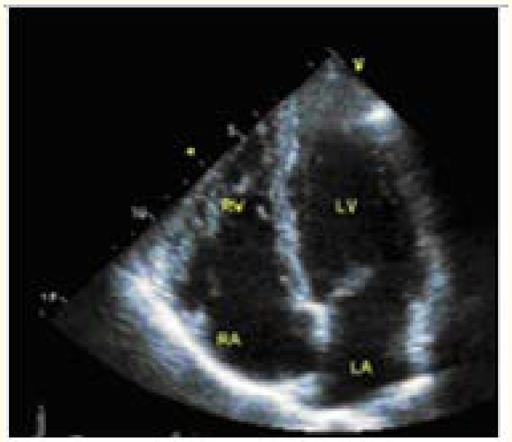

Figure I: Baseline 4-Chamber Echocardiographic view. RA = right atrium, RV = right ventricle, LA = left atrium, LV = left ventricle.

Figure II: Few fine emboli can be seen in the RA (Grade 1 embolism).

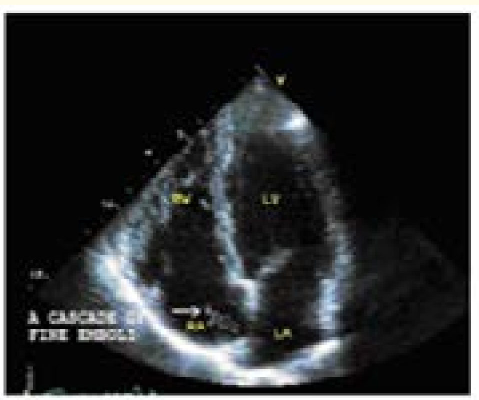

Figure III: A cascade of fine emboli or embolic masses with a diameter of < 5 mm. (Grade 2 embolism).

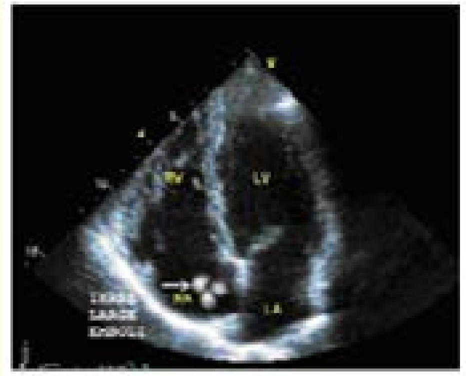

Figure IV: Three large emboli in RA following hip joint relocation with a diameter >5mm (Grade 3 embolism).

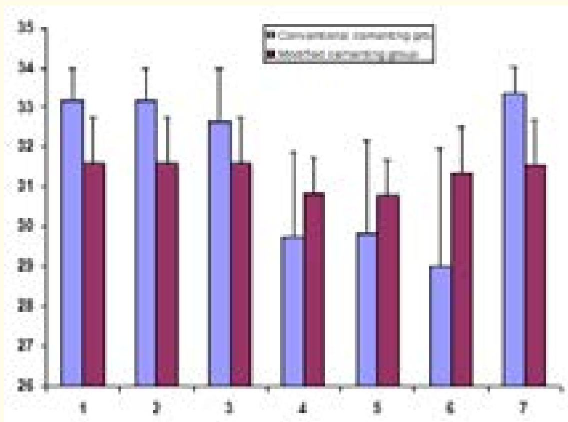

Figure V: The End tidal CO_2 (in mm Hg) in both groups during the different stages of the operation (mean ± SD).

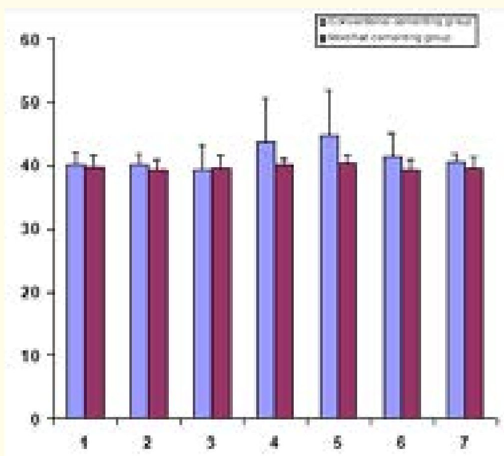

Figure VI: The arterial CO_2 tension (in mm Hg) in both groups during the different stages of the operation (mean ± SD).

Discussion

A number of cardiovascular and pulmonary complications e.g. acute hypotension, hypoxia, decreased cardiac output, increased pulmonary shunt values, elevated pulmonary-artery pressure and cardiac arrest have been reported to occur occasionally after insertion of a cemented total hip [5-8]. The most frequent cause of intra- and postoperative complications is the embolisation of fat, bone marrow, and bone debris into the lungs [5,9,10]. The rise of intramedullary pressure produced by the mechanical compression of the femoral canal during the insertion of the stem seems to be the decisive pathogenic factor for the development of embolism [11]. The thin-walled vessels in the medullary cavity can easily be disrupted by focal application of compressive loads, allowing the intravasation of bone marrow, fat, bone debris and embolisation through the venous system located along the linea aspera and through the metaphyseal vessels [12].

Cardio-respiratory effects of fat and bone-marrow embolism have been examined in clinical practice, particularly after insertion of the femoral component with a conventional cementing technique [13,14]. Fibrinolytic and lipolytic enzymes within the pulmonary circulation may diminish the effects of the embolic insult and may explain the erratic clinical occurrence of complications [13]. Nevertheless, the sequelae of severe fat embolism in patients who have preexisting cardiopulmonary damage can be detrimental and can even lead to death.

The decision to insert a cemented or cementless stem is usually based on parameters such as the age, gender, weight, and activity level of the patient as well as, the quality of the bone and the anatomy of the proximal part of the femur, which are thought to be associated with the success or failure of the fixation of an implant in bone. On the other hand, the use of cementless procedure is not a solution as it is associated also with a rate of occurrence of pulmonary embolism [15]. So, the problem is not in the cement alone, but it is in the increased intramedullary pressure during the operation even in cementless procedure.

Modern techniques of implantation with cement [16,17], provide a maximum bone acrylic interlock by means of a combination of a lower viscosity of the cement and pressurization. However, these techniques generate extreme intramedullary pressures within the femoral canal, which often exceed the pressures in the general venous circulation and cause a disruption of the thin-walled medullary vessels. The disruption of the vessels allows the intravasation and flow of fat, bone marrow, bone debris, and polymethylmethacrylate through the natural drainage system of the diaphysis, located along the linea aspera, and through the metaphyseal veins [5]. A number of investigators have stressed the important role of changes in intramedullary pressure in the genesis of intraoperative embolism [11]. In an *in vitro* study of fixation of the femoral component with and without cement, Inadome., *et al*. [18], found that, the pressures during the insertion of the femoral component with cement were markedly higher than those during insertion without cement. Furthermore, the elevation in pressure consistently persisted much longer when polymethylmethacrylate was used. Some operative measures during the insertion of the stem, particularly in arthroplasties performed with cement, may substantially minimize the amount of widespread systemic delivery of embolic material. Moreover, pulsatile lavage has been shown in experiments to decrease the volume of fat emboli as well as the resultant respiratory changes [19]. However, it does not eliminate the increase in pulmonary shunt volume associated with fixation of the stem with cement [6,20]. In the past, venting of the femoral canal has been recommended to avoid an increase in intramedullary pressure and intravasation of fat and bone marrow [10]. However, a simple drill-hole in the cortex was not found to be adequate to relieve intramedullary pressure in clinical practice. Furthermore, obstruction and migration of cement outside the femoral canal were quite frequent, resulting in the abandonment of this technique. The intramedullary pressure (the pressure within the femoral canal) sometimes markedly increases during operation so that; it exceeds the pressures in the general venous circulation and cause a disruption of the thin-walled medullary vessels. The disruption of the vessels allows the intravasation and flow of fat, bone marrow, bone debris, and polymethyl-methacrylate through the natural drainage system of the diaphysis, located along the linea aspera, and through the metaphyseal veins [5,21]. A number of investigators have stressed the important role of changes in intramedullary pressure in the genesis of intraoperative embolism [11,22]. So, the surgical technique is modified by certain methods to avoid the increase in the intramedullary pressure and thus preventing the risk of embolism of medullary content during the operation, these methods include: The venting hole technique [10,11], proximal drainage technique, [6,19,20], bone-vacuum technique (proximal and distal drainage technique) [12,20], use of a stem that has a long central cannula for the evacuation of medullary content during insertion [23]. Use of cutting tools coated with a fine, pure diamond surface instead of broaches [24].

The purpose of this study was to assess the efficacy of modified cementing technique designed to reduce intraoperative embolic phenomena.

In this study, the demographic data were comparable in both groups of patients, so the incidence of pulmonary embolism was not affected by the age, sex, body weight, height, duration of the operation, estimated blood loss and the preoperative anesthesiological status. Sharrock., *et al*. [25], Lemos., *et al*. [26], Jiganti., *et al*. [27] and Benjamin., *et al*. [28] found that, obesity was not a risk factor for perioperative thrombo-embolic events in patients undergoing primary hip replacement surgery. Finally, Rocco., *et al*. [24], agree with our opinion that demographic characteristic do not affect the incidence of fat embolism during total hip arthroplasty in the study carried out on 60 patients comparing the effect of fixation of the femoral component with conventional cementing technique, fixation with use of a bone-vacuum cementing technique and without cement for the prevention of embolism during the operation.

In contrast to this study, Carlos., *et al*. [29], found that, obesity increases the likelihood of pulmonary embolism in the 10 years study carried out on 9791 patients undergoing primary hip arthroplasty, also Mantilla., *et al*. [30], White., *et al*. [31], Kim., *et al*. [32] and Lowe., *et al*. [33] found that, increasing age has been associated with increased thromboembolic risk in the orthopedic population and this not agree with the results of this study. The differences between this study and these studies may be due to large number of the patients included and use of different population as the genetic influence may place specific patient population at increased thromboembolic risk [34].

This study showed that; application of a vacuum suction along the linea aspera decreased the embolization of fat and bone marrow during the insertion of the stem. In agreement to this study, Draenert., *et al*. [12], Pitto., *et al*. [5] and Pitto., *et al*. [35] in their experimental study showed a marked under pressure within the femoral canal by using the modified cementing technique. The same opinion was reached by Pitto., *et al*. [20], Matthias., *et al*. [36] and Rocco., *et al*. [24].

In this study, in the conventional cementing group, heart rate increased significantly with grade 2 or 3 embolism after insertion of the stem and relocation of the hip joint, but the heart rate showed insignificant increase in the patients with modified cementing group. Pitto., *et al*. [37], found the same findings in his study but in contrast to this study [20], Matthias., *et al*. [36], Rocco., *et al*. [24] did not find any variation in heart rate in response to embolic events, the difference in the change in heart rate may depend on the grade of embolism (grade 1 embolism did not cause changes in heart rate).

In this study, decrease of arterial blood pressure had been reported in the conventional cementing group with grade 2 or 3 embolism especially after insertion of the stem and relocation of the hip joint. Patients of group 2 did not present with marked change of the blood pressure. This confirms the results of other investigators e.g. Pitto., *et al*. [37], Matthias., *et al*. [36], and Rocco., *et al*. [24].

In this study, there was a decrease of arterial oxygen saturation, end-tidal carbon dioxide, arterial oxygen tension and increased arterial carbon dioxide tension in response to grade 2 or 3 embolism in the conventional cementing group. This confirms the clinical observations of other investigators [20,24,36,37].

The pulmonary artery pressure measured by Echocardiography in our study showed significant increase in the conventional cementing group patients after insertion of femoral stem and relocation of hip joint, but in patients with modified cementing technique, PAP showed insignificant changes.

No patients had cardiac arrest in our study. In agreement to our study, Rocco., *et al*. [24], Pitto., *et al*. [37], found the same results but in contrast to our study, Patterson., *et al*. [7], reported that, 7 patients had cardiac arrest during total hip arthroplasty with cemented long stem femoral component, 4 of those 7 patients died in operating room.

The difference between our study and this study may be due to presence or absence of factors that affect the outcome e.g. advanced age, degree of osteoporosis of bone (The low mechanical resistance of the weak trabeculae in osteoporotic bone may allow a considerable amount of fat and bone-marrow elements to enter the drainage veins of the femur and to reach the systemic circulation), a previously undisturbed intramedullary canal, use of long stem femoral component and several patches of methylmethacrylate.

Conclusion

We concluded that the modified surgical technique (A vacuum drainage of the proximal femur along the linea aspera) that was found to be effectively reduced the incidence of embolization during cemented hip arthroplasty. The modified technique reduces high intra-medullary pressure and the migration of fat and bone marrow into the venous system thus, leading to reduction of severe embolization.

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