A-mode Ultrasound Analysis of Postoperative Thigh Edema in Patients with Hip Fracture

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Postoperative edema and lean body mass may contribute to functional outcome in frailty hip fracture patients. Advances in body mass determination have produced consistent results with A-mode ultrasound. We therefore aimed to determine the utility of A-mode ultrasound in analyzing postoperative limb edema in patients receiving treatment for proximal femur fractures. 4 males and 6 females, with an average age of 74.3 years were included. 4 had fractures of the femoral neck treated by hemiarthroplasty and the rest had extracapsular fractures which were stabilized with short intramedullary nails. Measurements were done using a commercially available A-mode 2.5MHz transducer on the thighs approximately 15 cm proximal to the patella. Comparison showed significant difference between the operated and contralateral thigh circumference (P=0.001) as well as muscle layer thickness differences between femoral neck patients and those with fractures of the trochanteric region (P=0.016). There was no correlation between the A-mode ultrasound determined superficial layer difference and entire layer difference (R^2=0.037; P=0.59). However, there was linear correlation between the A-mode ultrasound determined entire layer difference and limb circumference difference, (R^2=0.414; P=0.044). Postoperative thigh edema is present in all surgically treated patients for proximal femur fractures. A-mode ultrasound might be a reliable tool to examine adipose and muscle layers separately in the immediate postoperative period. There may be a difference in edema distribution between femoral neck and peritrochanteric fractures but larger samples are required.

Key words: hip fracture; postoperative edema; A-mode ultrasound; arthroplasty; Gamma Nail

Fractures of the proximal femur represent a burden of the modern civilization [1]. These are debilitating conditions arising in a frail, elderly population. Treatment options are aimed at restoring bone continuity, identifying osteoporotic patients at risk and providing adequate measures to regain functional independence for activities of daily living.

Research has focused mostly on bone quality (osteoporosis) and surgical implants [2]. However, recent studies aimed at posttraumatic recovery have shown that postoperative edema and lean body mass may also determine functional outcome. The causes of lower limb swelling are plurifactorial and not completely understood [3]. Advances in body mass determination have produced consistent results with A-mode ultrasound. This technology can provide accessible identification of soft tissue stratification [4, 5]. We therefore aimed to determine the utility of A-mode ultrasound in analyzing postoperative limb edema in patients receiving treatment for proximal femur fractures.

Experimental part

We performed a cross-sectional pilot study on patients admitted in our Hospital for hip fracture treatment. 10 patients were included and all gave informed consent. Demographic data is presented in table 1. There were 4 males and 6 females, with an average age of 74.3 years. 4 had fractures of the femoral neck and were treated by hemiarthroplasty via a lateral approach using press-fit stems and bipolar heads (Biomet, Warsaw, USA). The rest had fractures in the trochanteric region which were closely reduced and internally stabilized with short intramedullary nails (Stryker, Kalamazoo, USA). The surgeries were performed on an emergent basis under spinal anesthesia by several surgeons. Neutrophil/ Lymphocyte Ratio from the preoperative and the last postoperative standard Lab results was used as a marker for inflammation to potentially identify early complications as described in the literature [6, 7]. Measurements were done by the same investigator using a commercially available A-mode transducer BodyMetrix™ BX2000 (IntelaMetrix,Inc., Livermore,CA) 2.5MHz and proprietary body mass software Body View 2D. With the patient supine and the knees extended, a ruler was used to determine a point on the femur approximately 15 cm proximal to the top of the patella (fig. 1). The circumference was determined on both the operated (study) and contralateral (control) thighs using a tape for control. At this same level, the transducer was then moved twice from medial to lateral for a surface length of approximately in a transverse fashion to the thigh long axis. Care was taken not to over press the transducer on the skin whilst maintaining continuity and also to keep in pointing at the femur. At this level the region is easily accessible and also relatively thin which allows comfortable penetration for a large group of patient types. This resulted in a graphical depiction of the soft tissues as described by Wagner and exemplified in figure 2 [4]. The first – superficial – layer corresponds to the subcutaneous fat and the second major line of separation is at the bone – surface interface. The contralateral limb was used as control for comparison. Linear regression and t-test were

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used for the statistical analysis, computed via QuickCalcs (GraphPad Software, San Diego, USA).

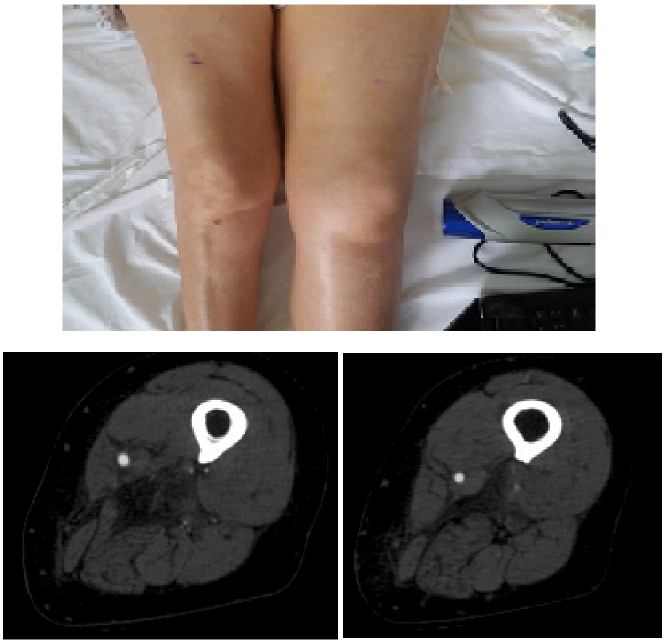

Fig. 1. Technique example: A.with the patient supine and the knees extended the desired level for the measurement was marked on the skin; thigh circumference was obtained first followed by ultrasound exploration; B.axial CT (didactic sample of a computed tomography with contrast) images approximately at the level of the measurements to show the anatomy in the region of interest;

a significant comparison of the muscle layer (entire layer minus superficial layer) size differences (operated to contralateral) between femoral neck patients and those with fractures of the trochanteric region, (P=0.016, 95% CI: -7.9495 to -1.0472, Means-0.055 and 4.443 and SD 1.136 and 2.797).

There was no linear correlation between the A-mode ultrasound determined superficial layer difference (X) and entire layer difference (Y) (95% Confidence Interval: -1.40 to 2.30; R square = 0.037; P Value = 0.59) (fig. 3 A). However, there was linear correlation between the A-mode ultrasound determined entire layer difference (X) and limb circumference difference (Y), (95% Confidence Interval: 0.129 to 8.28; R square = 0.414; P Value = 0.044), (fig. 3 B).

From our study we have learned that A-mode ultrasound can be an easily adapted and relatively inexpensive commercially available method to explore layer distribution of the postoperative thigh edema in patients surgically treated for proximal femur (hip) frailty fractures. To the best of our knowledge this is the first attempt to publish such results. We were able to show that A-mode ultrasound determination of soft tissue correlates with the well-established measure of thigh circumference 15 cm proximal to the proximal pole of the patella. Determination was performed on the anterior aspect of the distal thigh. Although this region is not expected to be deeper than 60mm, we chose to use a 100mm (maximum) window to cover potentially large patients or extreme edema.

There is currently no consensus on determining muscle condition after fracture surgery. Current concepts revolve

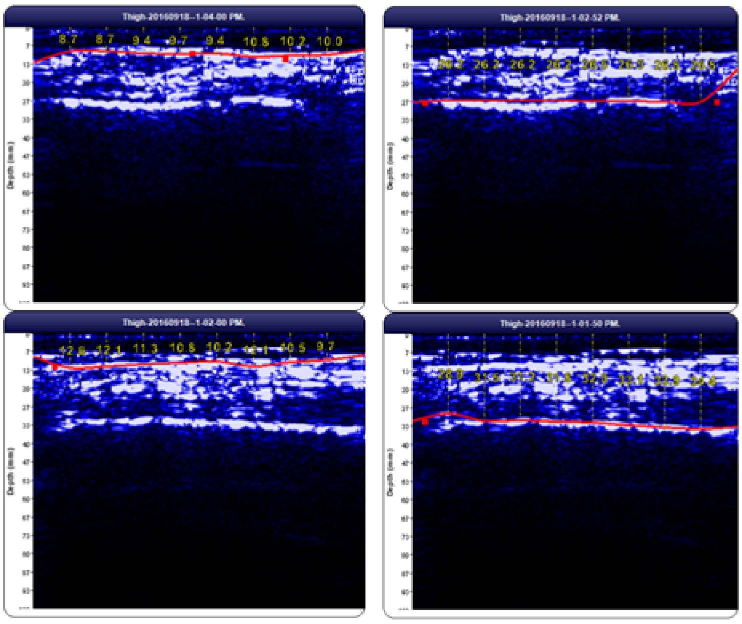

Fig. 2 Example of the comparative measurements of the superficial and deep layers in the control and operated limb; in this case for patient No.6

Results and discussions

The layers in the A-mode ultrasound determinations were manually tracked using the software function do determine depth. The 8 automatically generated numbers (fig. .2) were extracted and averaged for each determination using Excel software (Office 2010, Microsoft, USA). The results are presented in table 2.

The paired t-test comparison showed significance between the operated and contralateral thigh circumference (P=0.001, 95% CI 1.622 to 4.578, Means 47.1 and 44.0 and SD 5.38 and 6.16). The paired t-test comparison showed a marginally significant decrease in the pre and postoperative NLR (neutrophil lymphocyte ratio) (P=0.057, 95% CI -0.06 to 3.80, Means 47.1 and 44.0 and SD 5.38 and 6.16). In addition, unpaired t-test produced

around tests that are often difficult to perform in this population especially in the perioperative period [8, 9]. In addition, decreased lean body mass is associated with decreased bone density and an independent risk factor for fracture [10, 11]. We consider that this simple A-mode ultrasonography can provide useful dynamic data on lean body mass determinants and edema predominance among soft tissue layers.

We stipulated that in our patients, edema most likely develops due to increase capillary permeability and imbalance between the hydrostatic and colloid osmotic forces as previously described in the literature [12]. Other factors may also contribute to postoperative edema such as hematoma management or infection [13, 14]. Kazmi et al have showed that postoperative edema is higher in the first week after surgery (most on the 7-th day) and also

N	Gender (1-male)	Age (years)	Diagosis (fracture)	Days operated	Height (cm)	Weight (kg)	BMI	PreOp NLR	PostOp NLR
1	0	80	Trochanteric	1	160	75	29.3	11.11	4.64
2	1	69	Trochanteric	1	178	85	26.8	3.37	4.58
3	0	61	Neck	2	160	55	21.5	5.91	5.75
4	0	76	Trochanteric	3	165	90	33.05	5.50	3.33
5	0	73	Trochanteric	6	165	60	22.03	9.58	3.83
6	0	84	Trochanteric	8	163	62	23.3	5.23	1.66
7	1	76	Neck	16	186	86	24.8	8.36	6.21
8	1	76	Neck	4	186	108	31.2	3.77	5.07
9	1	70	Neck	11	178	75	23.7	4.12	3.55
10	0	78	Trochanteric	11	165	85	31.2	5.19	4.86

Table 1
DEMOGRAPHIC DATA OF THE STUDY PATIENTS; BMI = BODY MASS INDEX; NLR = NEUTROPHIL LYMPHOCYTE RATIO

N	Superficial Layer (mm)		Difference (mm) Superficial Layer	Entire layer (mm)		Difference (mm) Entire layer	Thigh perimeter (cm)		Difference (mm) Thigh perimeter
	Op	Control		Op	Control		Op	Control	
1	12.65	9.875	2.78	28.25	22.71	5.54	47.5	44.5	30
2	7.92	6.13	1.79	50.26	41.16	9.1	52	50	20
3	17.76	12.5	5.26	23.83	17.77	6.06	38	34	40
4	19.71	16.07	3.64	43.37	38.05	5.32	55	52	30
5	11.16	9.61	1.55	32.1	26.47	5.63	46	40	60
6	16.72	15.01	1.71	32.98	22.82	10.16	45.5	38.5	70
7	8.27	6.1	2.17	21.98	21.52	0.46	41	40.5	5
8	12.67	9.95	2.72	29.14	25.87	3.27	47	45	20
9	7.37	6.82	0.55	23.26	22.57	0.69	45.5	43	25
10	19.5	18.41	1.09	42.11	38.64	3.47	54	53	10

Table 2
A-MODE ANALYSIS OF THE THIGH COMPARED TO LIMB DIAMETER; THE SUPERFICIAL LAYER CORRESPONDS TO THE ADIPOSE TISSUE WHEREAS THE ENTIRE LAYER CORRESPONDS TO BOTH ADIPOSE AND MUSCLE TISSUE TOGETHER

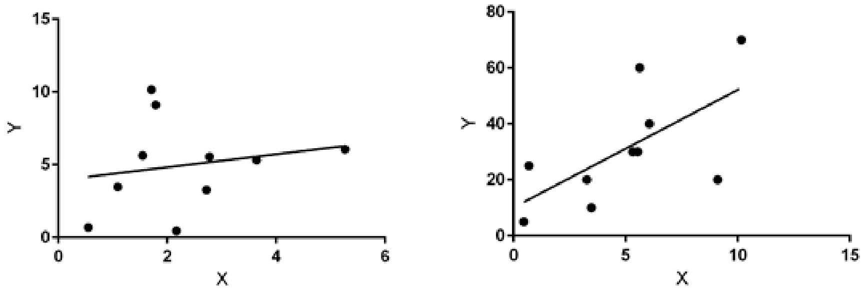

Fig. 3 Graphic representation of the linear regression calculation between:
A. ultrasound determined superficial layer difference (X) and entire layer difference (Y); P = 0.59. B. ultrasound determined entire layer difference (X) and limb circumference difference (Y); P=0.044

that extracapsular fractures produce a bigger inflamatory response compared to femoral neck [3, 12]. In our sample there appears to be differences of edema distribution in the adipose and muscle layers between patients with femoral neck – hemiarthroplasty and those with extracapsular fractures – osteosynthesis. Nevertheless, our results should be interpreted with caution due to the small and relatively heterogeneous sample of subjects and cross sectional design. A further, longitudinal, larger sample study is currently in progress and should bring better statistical power. A-mode ultrasound has been proven a reliable method to determine body fat composition yet some limitations have appeared. It can accurately track changes in body fat content yet it relies on technician skills. Studies have compared it to BMI (body mass index), skinfold caliper, B-mode ultrasound, DXA (dual-energy X-ray absorptiometry), CT (computed tomography) and research methods such as air displacement plethysmography (ADP), also known as BOD POD [5, 15, 16].

Conclusions

The postoperative thigh edema is present in all surgically treated patients for proximal femur fractures. A-mode ultrasound might be a reliable tool to examine adipose and muscle layers separately in the immediate postoperative period. There may be a difference in edema distribution between femoral neck and peritrochanteric fractures but larger samples are required.

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