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Original Article

Ultrasonographic evaluation of haemodynamic flow changes to the hip in systemic lupus erythematosus patients: Correlation with risk factors for osteonecrosis

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ABSTRACT

Aim of the work: To evaluate haemodynamic changes in the femoral head in systemic lupus erythematosus (SLE) patients and to compare these haemodynamic changes between SLE patients with or without associated risk factors for ON. To determine the effect of various risk factors on the blood flow to the proximal femur.

Patients and methods: Evaluation of the blood vessels supplying the femoral heads bilaterally [medial and lateral circumflex femoral arteries (MCA and LCA)], by color and power Doppler (CD/PD) ultrasound (US). Arterial pulsatility index (PI) and peak systolic velocity (PSV) were determined in both neutral and internal rotation positions (simulated ischemia).

Results:

- Both the PI and PSV values were significantly higher in SLE patients with associated risk factors for ON compared to those with no associated risk factors for ON ($p < 0.05$).
- The PI value correlated inversely with PSV in both SLE patients and controls ($p < 0.05$).
- PSV increased simultaneously with the decline of PI value in both SLE patients and controls after internal rotation of the femoral head (simulated ischemia).
- The PI showed significant direct correlation with steroid dose ($p = 0.04$), but not the duration of steroid use ($p = 0.47$), Raynaud's phenomenon ($p = 0.03$) and serositis (pleural effusion) ($p = 0.02$).

Conclusion: The presence of associated risk factors for ON contributes to haemodynamic flow changes. Color Doppler ultrasound represents a useful tool for the assessment and follow-up for haemodynamic deterioration of hip vascularity in both hip joints.

1. Introduction

Osteonecrosis (ON) is a clinical entity of unclear pathogenesis characterized by death of the bone marrow and the trabecular bone. It often results in collapse of the architectural bone structure, leading to joint pain and loss of function. Circulatory impairment of the affected bone is common for all cases of ON [1]. Compromise of the bone vasculature causing bone death and mechanical failure ends within a period of two years in most patients [2,3].

Avascular necrosis describes the occurrence of necrosis in the epiphysis of long bones such as the anterolateral aspect of the femoral head [4]. It may follow trauma resulting in interruption of the blood flow or may complicate the course of systemic diseases however, in some cases, an underlying factor cannot be reached [5]. Glucocorticoids have been implicated as risk factors for osteonecrosis in SLE [6], however the literature has reported the development of ON in SLE patients not receiving treatment with this drug [7]. Disease associated conditions including disease activity, vasculitis, Raynaud's phenomenon, thrombophlebitis, antiphospholipid antibodies, thrombophilia and hypofibrinolysis increase the risk of ON development [8].

The medial circumflex femoral (MCF) and lateral circumflex femoral (LCF) arteries form an extracapsular ring surrounding the base of the femoral neck, supplying blood to the proximal end of the femoral head [9,10]. The epiphysis and most of the femoral neck are intracapsular, which subjects the ascending cervical branches of the MCF and LCF arteries (the retinacular vessels) to increased hydrostatic pressure in the hip joint. Positioning of the hip in extension and slight internal rotation leads to increased intracapsular pressure and

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temporary mechanical compression of retinacular vessels [11].

The aim of this work is to evaluate haemodynamic changes in the femoral heads in systemic lupus erythematosus (SLE) patients before the development of osteonecrosis (ON) and to compare these haemodynamic changes between SLE patients with no associated risk factors for ON and those with associated risk factors for ON. To determine the effect of various risk factors for ON on the blood flow to the proximal femur.

2. Patients and methods

Forty female systemic lupus erythematosus (SLE) patients, fulfilling the American College of Rheumatology 1982 revised criteria for the classification of SLE [12] were included in this study. Patients were selected from the Rheumatology and Rehabilitation Department, Faculty of Medicine, Cairo University Hospital. Patients' age ranged from 17 to 54 years with a mean of 30.32 ± 9.64 years. Disease duration ranged from 1 to 11 years, with a mean of 5.21 ± 1.52 years. Twenty healthy females of matching age served as the control group. An informed consent was obtained from the patients after explaining the purpose and procedures of the study. The study was approved by the ethical committee of the Faculty of Medicine, Cairo University.

SLE patients were further classified according to the presence or absence of associated risk factors for osteonecrosis (ON) into two groups:

- Group A included 20 SLE patients with no associated risk factors for ON.
- Group B included 20 SLE patients with associated risk factors for ON: disease duration > 5 years; SLEDAI score > 8; symptoms or signs suggestive of Raynaud's phenomena or vasculitis; abnormal lipoprotein profile; positive IgM/IgG anticardiolipin antibodies (ACA) and daily corticosteroid dose > 10 mg within the last 6 months.

Patient and control subjects were subjected to thorough clinical examination including detailed hip joint examination. Laboratory investigations including complete blood count (CBC), erythrocyte sedimentation rate (ESR), antinuclear antibodies (ANA) by immunofluorescence technique, anti-double stranded deoxyribonucleic acid antibodies (anti-ds DNA), quantitative estimation of serum complement levels (C3 and C4), IgM/IgG ACA using ELISA, serum aspartate transaminase (AST); alanine transaminase (ALT) (U/l), blood urea and serum creatinine (mg/dl) and complete urine analysis including estimation of 24-hour urinary proteins. Lipid profile: total cholesterol, high-density lipoproteins (HDLs), low density lipoprotein (LDLs) and triglycerides (TGs).

Disease activity was assessed according to the systemic lupus erythematosus disease activity index (SLEDAI) [13].

2.1. Radiologic investigations

Plain radiographs of the hip joints and pelvis (anteroposterior/axial) were obtained for SLE patients to exclude evidence of osteonecrosis or congenital hip dysplasia.

2.2. Evaluation of hemodynamic flow to the hip joint

Colour and power Doppler (CD/PD) ultrasound (US) on the medial and lateral circumflex femoral arteries of both hip joints were performed for patient and control subjects using standard ultrasound equipment (Siemens Sonoline Elegra) with a 5 MHz linear array transducer. The equipment was operated utilizing flow sensitivities as low as 3 cm/s with flow velocity measurements under angle correction (< 65 degrees). The medial circumflex femoral artery (MCF) was located by searching the posterior or medial aspect of the common femoral artery where it originates (70%), or from the posterior aspect of the profunda femoris artery (30%). The lateral circumflex femoral artery (LCA) was located by exploring the lateral aspect of the proximal portion of the profunda femoris artery (90%), or the distal part of the common femoral artery [14].

The ability of Doppler US to demonstrate flow changes has increased efforts to derive quantitative values that determine the percentage of flow in a blocked vessel. The pulsatility index (PI) is one of the calculated flow parameters.

$$\mathrm{PI} = \frac{\nu\mathrm{max} - \nu\mathrm{min}}{\nu\mathrm{mean}} = \frac{S-D}{mean}.$$

The maximum velocity is referred to as the systolic velocity (S) and the minimum velocity is referred to as the diastolic velocity (D). The mean estimated velocity (νmean) is related to the mean Doppler shifted frequency shifts $f$mean [15].

Arterial pulsatility index (PI) and peak systolic velocity (PSV) were determined in both the neutral and internal rotation positions (simulated ischemia). PI values were calculated by a pre-established algorithm using the Gosling equation: PI = (PSV − EDV)/mean velocity (EDV is the end-diastolic velocity) [14].

The PSV in the common femoral artery was used as a reference for each patient to detect the significance of the change in the PSV of the circumflex femoral arteries. The major criterion for Doppler diagnosis of arterial stenosis is a focal increase in PSV. Blood flow velocity varies according to lumen status. The calculated PSV is used for characterizing arterial hemodynamics, since flow velocity usually increases in a stenotic lumen. The PI will decrease as flow is impeded by a stenosis [14].

2.3. Statistical methods

Data were collected, tabulated and statistically analyzed using computer program Microsoft Excel 2003 (Microsoft Corporation, NY, USA) and SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows operating system. Data were statistically described in terms of mean, standard deviation and range. Comparison of quantitative variables between the study groups was done using Kruskal Wallis analysis of variance (ANOVA) test with Mann Whitney U test for independent samples as post hoc multiple 2-group comparisons. Within group, comparison of quantitative variables was done using Wilcoxon signed rank test for paired (matched) samples when not normally distributed. Correlation between various variables was done using Spearman rank correlation equation for non-normal variables. A probability value (p value) less than 0.05 was considered statistically significant and highly significant at < 0.01.

3. Results

Forty female systemic lupus erythematosus (SLE) patients, fulfilling the American College of Rheumatology 1982 revised criteria for the classification of SLE [12] were included in this study. Twenty healthy females of matching age served as the control group.

SLE patients were equally classified according to the presence or absence of associated risk factors for osteonecrosis (ON) into two groups:

- Group A included 20 SLE patients with no associated risk factors for ON.
- Group B included 20 SLE patients with associated risk factors for ON.

The age of SLE patients in group A ranged from 18 to 43 years with a mean of 30.32 ± 9.14 years. Disease duration ranged from 1 to 4 years with a mean of 2.71 ± 1.26 years. The age of SLE patients in group B ranged from 17 to 54 years with a mean of 30.35 ± 10.15 years. Disease duration ranged from 5 to 11 years with