Pattern of Innervation of the Upper Gluteus Maximus Muscle: Implication in Prosthetic Hip Dislocation

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Abstract

Background: Dislocation is one of the most common complications after total hip arthroplasty. The posterolateral approach avoids disruption of the abductor mechanism but may denervate gluteus maximus as a basis for associated higher dislocation rates.

Objective: To determine the pattern of innervation of gluteus maximus

Study design: Descriptive cross-sectional study

Materials and methods: Twenty four cadavers for routine dissection in the Department of Human Anatomy, University of Nairobi were used. Having exposed the gluteus maximus, the muscle was transected close to its distal attachment and reflected superiorly to expose the entry of the neurovascular structures into it from the greater sciatic foramen. The pattern of distribution of the inferior gluteal nerve to the muscle was noted and the left and right in the same cadaver compared

Results: In all the 48 cadaver sides, the inferior gluteal nerve exited the pelvis via the infra-piriformic compartment of the greater sciatic foramen. In majority (43, 89.6%) of gluteal regions this nerve funned out in multiple equal branches to the GM. Only one branch crossed the upper border of piriformis muscle. In 5 cases, this single branch that crossed the upper border of piriformis was a major trunk almost equal in size to the parent nerve. One such case was bilateral.

Conclusion: A major branch of the inferior gluteal nerve to the upper part of GM, when present, could be injured in the posterior approaches to the hip to significantly weaken the upper part of this muscle increasing the risk of prosthetic hip dislocation.

Introduction

Gluteus maximus (GM) is a powerful hip extensor innervated by the inferior gluteal nerve (IFN) and an important muscle in rising up from squatting position, climbing (1) and running (2). Its functions during running are to control flexion of the trunk on the stance-side (3) and to decelerate the swing leg. Low levels of GM activity may contribute to hip extension during stance, and to restrain hip flexion during swing. During loading response of the gait cycle, in the frontal plane, activity in the upper portions of the gluteus maximus, hip abductors and tensor fascia lata control drop of the contralateral pelvis, which is relative hip adduction (4).

Risk factors in prosthetic hip dislocation include patient-related ones such as neuromuscular disease (5) and surgical ones. Of the surgically-related factors, the approach has generated a lot of controversy. In the Moore posterior approach to the hip the incision starts 10 centimetres from the posterior superior iliac spine, is directed laterally and distally to the back of the greater trochanter and extends for 10 or more centimetres, parallel to the shaft of the femur. The deep fascia is exposed and the iliotibial band is incised from the trochanter to the distal end of the incision. The fascial incision is then carried into the gluteus maximus muscles separating the oblique, coarse fibres in the direction of the skin incision (6). Branches from the IFN to GM run predominantly inferiorly to where the bulk of the muscle mass is (7). By dividing the fibres of GM in a plane above piriformis muscle in this approach, the rationale is that only the upper part of GM is dennervated, a loss considered insignificant to the muscle's functions.

After the series by Woo and Morrey (8) and later by Morrey (9), the posterior approaches have been thought to predispose to instability. Recent studies incorporating posterior capsular and short external rotators repair have revealed comparative dislocation rates to the direct lateral approach (10-12). Studies by Stähelin et al (13,14) demonstrating failure of some of these posterior soft tissue repairs suggest another patient-related factor that would help explain the variability in dislocation rates by various series. Since it is documented that the upper part of GM helps in the control of drop of the contralateral pelvis during loading response of the gait cycle (4), could it be that variability in the pattern of innerva-

tion of this part that is dennervated during the posterior approach has a contribution to rates of prosthetic hip dislocation? The aim of this study was therefore to determine the pattern of innervation to the gluteus maximus focusing mainly on its upper part.

Materials and methods

Twenty four formalin-fixed adult human cadavers used for dissection by first year medical students at the University of Nairobi were used. With the cadaver lying prone on the dissection table, the skin and superficial fascia of the gluteal region was dissected off to expose the entire GM on both sides of the natal cleft from the iliac crest and sacrum to the iliotibial band and gluteal tuberosity. With blunt digital dissection, the distal part of the muscle was separated from the underlying structures. Using this plane of separation, an incision was made about an inch proximal to the gluteal tuberosity across the muscle fibres and the muscle lifted superiorly to expose the structures underneath it and the neurovascular supply to it. Careful separation of the neurovascular structures from the greater sciatic foramen to GM was done. The inferior gluteal nerve was then identified and its pattern of branching noted. A line connecting the summit of the greater trochanter and the posterior superior iliac spine was used to determine the number of nerve branches that ran above it to the upper portion of the GM attached to the iliac crest. This line ran through the fibres of piriformis muscle.

Results

The inferior gluteal nerve (IFN) was the sole source of innervation to the GM in all the 48 dissected gluteal regions. It arose from the pelvis through the greater sciatic foramen inferior to piriformis muscle.

The IFN divided into three to five branches after its exit from the greater sciatic foramen and the branches spread out in a 'bird's foot' manner to the GM (Fig. 1A). In all cases, only the superior most branch was noted to lie above the upper margin of piriformis muscle. In five gluteal regions (one bilateral) this superior branch was almost as big as the parent nerve (Fig. 1B).

Discussion

During surgical exposures, an attempt is made to exploit inter-nervous planes, or where a muscle has dual innervation, a split in the middle of such muscle is made (15). Situations arise however, where a muscle is split along its fibres but caution exercised by use of stay sutures to prevent disruption of its innervation as the nerve branches course across the muscle fibres as in the Hardinge technique of the lateral approach to the hip joint (6).

This study has shown that in a few cases, the innervation of the upper portion of gluteus maximus is by a major branch of the inferior gluteal nerve. Split in the GM along its fibres therefore risks traction or laceration of this branch as in the posterior approaches to the hip (16). That the upper portion of GM assists gluteus medius and minimus in hip abduction mechanisms (4,17), injuries to a major branch to this portion of GM negates the whole idea of preservation of the hip abductors through the posterior approaches.

More than half of all dislocations occur within the first 3 months postoperatively and more than three fourths occur within 1 year (8). Based on studies by Stähelin et al (13-14) on failures within three months post-operative of some of the techniques in capsular enhanced repairs of the short extensor rotator muscles, neuropraxia of a major branch to the upper portion of the GM may be a contributory factor in these early dislocations. Muscle function would improve eventually as the nerve recovers, consequently lowering the risk of dislocation.

Electromyographic studies on the upper portion of GM in patients undergoing the posterior approaches before and after the procedure would perhaps shed more light on the role of this muscle in the hip abduction mechanisms and stability.

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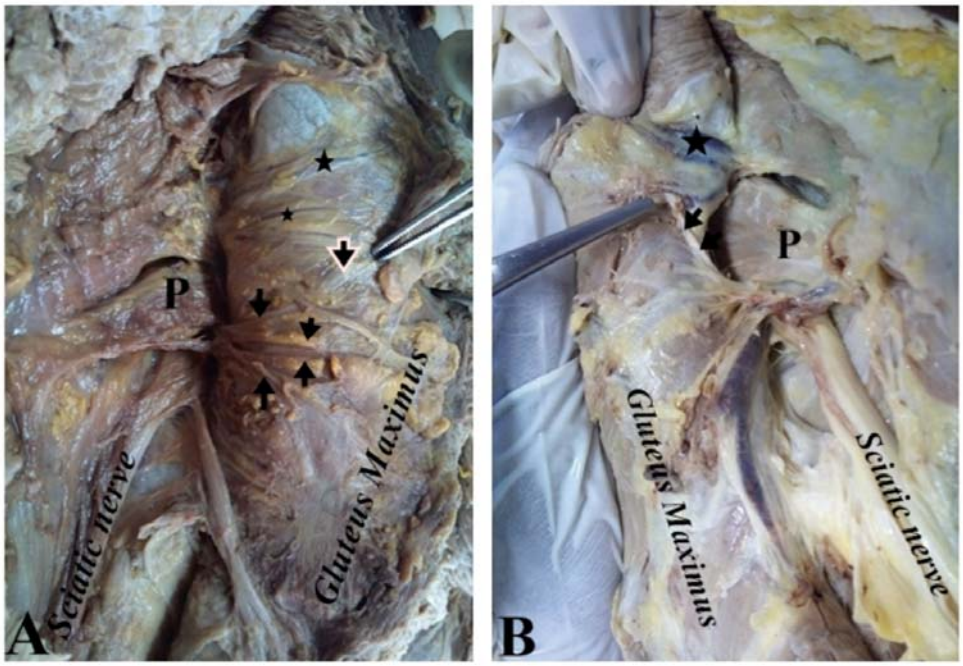

Fig. 1 A-B: Pattern of innervation of the gluteus maximus muscle. A: The inferior gluteal nerve dividing into four equal branches (black arrow heads) as it exits the greater sciatic foramen below piriformis muscle (P). Note the single branch to the upper portion of gluteus maximus (arrow head with white margin). B: A single major upper branch of inferior gluteal nerve to the upper portion of gluteus maximus is indicated by two arrow heads. The black stars denote the superior gluteal vessels.

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