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Anatomy, Bony Pelvis and Lower Limb, Saphenous Nerve, Artery, and Vein

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Introduction

The saphenous nerve, artery, and vein are integral structures of a neurovascular bundle that courses through the thigh and leg of the lower limb. Firstly, the saphenous nerve is a strictly sensory nerve with no motor function.[1] It is responsible for innervation to the anteromedial aspect of the leg. The saphenous artery, a distant branch of the femoral artery arising from the descending genicular artery, is the predominant vascular supply to the surfaces of the knee. The saphenous vein (greater and lesser) returns blood from the superficial surfaces of the leg, emptying into the femoral vein proximally.[2][3]

Embryology

During the gastrulation phase of the embryo, three germ layers are created—the ectoderm, endoderm, and mesoderm. The ectoderm itself is composed of two parts, the surface ectoderm, and the neuroectoderm. The neural crest, which derives from the neuroectoderm, gives rise to the peripheral nervous system which includes the saphenous nerve. On the other hand, the blood vessels that give rise to the saphenous artery and vein derive from the mesoderm. Although the blood vessels and nerves may originate from different germ layers, the vasculature corresponds with the consequent neuronal network. The Schwann cells that myelinate the peripheral nerves release vascular endothelial growth factor (VEGF) to stimulate the growth of the associated blood vessels of the neurovascular bundle.[4]

Blood Supply and Lymphatics

The saphenous artery typically branches from the descending genicular artery which originates from the medial wall of the femoral artery in the adductor canal. The saphenous artery, along with the saphenous nerve, travel under the sartorius muscle.[5] Once the saphenous artery is just proximal to the knee joint, there can be up to three cutaneous branches which supply the anterior and medial surfaces of the knee. Distal to the knee joint, there are more cutaneous branches to supply the anterior skin of the proximal third of the leg. The saphenous artery also has a muscular branch to supply to the sartorius muscle.[6]

The great saphenous vein is a subcutaneous vein that serves as the superficial vein of the leg. It initiates from the dorsal venous arch of the foot and runs anterior to the medial malleolus up to the medial aspect of the leg. It continues past the medial epicondyle of the femur to enter the saphenous opening where it drains into the femoral vein.[7][8][9]

Nerves

The saphenous nerve, the largest cutaneous branch of the femoral nerve, is derived from L3 and L4 of the lumbar plexus. This nerve has two major divisions known as the sartorial and infrapatellar nerves. These nerves together provide the sensory innervation to the medial,

anteromedial, and posteromedial aspects of the distal thigh to the medial malleolus of the ankle joint. The saphenous nerve begins in the proximal thigh as a posterior division of the femoral nerve which lies laterally to the femoral artery. The saphenous nerve then tracks through the adductor canal where at this point, the saphenous nerve is now medial to the femoral artery. Upon exiting the adductor canal, the nerve divides into the sartorial and infrapatellar nerve branches at the level of the medial femoral condyle of the femur. The infrapatellar branch immediately travels anteriorly and innervates the anteroinferior and medial aspect of the knee. [10]

The sartorial branch continues to travel down the medial knee and behind the sartorius muscle. The sartorial branch then tracks more superficially as it penetrates through the fascia between the gracilis tendon and the sartorius tendon. At this point, the sartorial branch continues with the long saphenous vein to provide sensory innervation to the medial leg and ankle. [11][12][13]

Physiologic Variants

Ordinarily, the saphenous artery is a vascular branch of the descending geniculate artery that is supplied by the femoral artery. However, some anatomical studies have shown an absent descending genicular artery. In this case, the saphenous artery originates directly from the femoral artery. The saphenous vein also has a multitude of variants that typically subclassify into five different types. The types are dependent on the relationship on whether the vein splits and/or if their location is within the saphenous compartment at the level of the thigh. [14]

Surgical Considerations

The saphenous vein is of considerable surgical significance because of its ability to serve as a coronary artery bypass graft (CABG), especially when medical therapy or percutaneous intervention is ineffective or not performable. In terms of graft choices for CABG procedures, both arterial and venous grafts have been used, with the saphenous vein being the most commonly used venous graft for the bypass. However, in CABG procedures, arterial grafts are more widely used and preferred due to their prolonged patency. Studies have indicated that 10-year patency rates for saphenous vein grafts are at 61% compared to arterial bypass grafts such as the internal mammary artery at 85%. [15] Nevertheless, there have been cases where the saphenous vein has remained patent for over 30 years. [16]

The patency of the saphenous graft can be affected by a multitude of factors such as disruption of the vasa vasorum that supports the graft and tissue handling during the anastomoses of the graft. The mismatch between the compliance of the grafted vein at the site of the anastomosis to the coronary artery can cause a hemodynamic imbalance which promotes decreased patency of the venous graft. [17]

When harvesting the saphenous vein for CABG procedures, careful attention is necessary on delineating the saphenous vein from the saphenous nerve. Particularly in the inferior third of the leg, the saphenous nerve and vein are adhered together by a common fascia. [18] Due to its anatomical proximity in the lower third of the leg, there is a high incidence of saphenous neuralgia; this causes either hyperesthesia or diminished sensation in the distribution of the saphenous nerve.

Iatrogenic saphenous nerve injury

While saphenous neuropathy following trauma accounts for less than 1% of adult patients presenting with lower extremity pain [19], the literature notes variable rates of saphenous nerve injury following various orthopedic procedures. For example, a 2017 study reported varying

degrees of sensory disturbances persisting up to and beyond 6-month follow-up in the majority of patients undergoing autograft hamstring (HS) harvesting during an anterior cruciate ligament (ACL) reconstruction procedure. The cohort consisted of oblique (n = 42) versus vertical (n = 36) incisional harvesting techniques, with 28 of 36 patients (77%) with the vertical incision experiencing sensory deficits at 6-months compared to 19 of 42 (45%) in the oblique incision cohort[20].

Depending on the technique used, the incidence of sensory disturbances in patients undergoing arthroscopic knee surgery has been reported as low as 0.06% up to as high as 77%. [21][22] With regards to meniscal repairs specifically, the reported range of saphenous nerve injury ranges from 1 to 20% of cases. [23][24]

The original belief was that the sartorial branch of saphenous nerve only becomes superficial at the medial joint line of the knee. So that during medical dissection of the knee, retraction of subcutaneous tissues would be protective of the sartorial branch of the saphenous nerve. However, there is anatomical variation where the saphenous nerve can become superficial above or below the joint line which can make it susceptible to injury during medial meniscus repairs. [25]

The saphenous artery also has significant surgical implications since a fasciocutaneous flap containing the saphenous artery can be elevated from the upper medial third of the leg and knee. These flaps can be utilized by reconstructive surgeons to cover defects of the upper extremities and exposed tibia after burns. [26]

Clinical Significance

Due to the saphenous nerve's purely sensory function, a regional blockade of the nerve can be of sizeable clinical significance for procedures terminal to the knee. Nerve blocks for ankle manipulation, particularly around the medial malleolus would be an effective method of pain management during such procedures. Blocks would also be of benefit for meniscectomies due to the saphenous nerve's course and location of innervation in the medial knee. [27]

The saphenous vein is also a commonly implicated vein in varicose veins that can lead to chronic venous disease. Structural changes can occur to the vein such as intimal wall thickening and increased connective tissue within the venous wall. The structural changes to the wall result in overall weakness and dilation of the vein which promotes reflux of flow. The reversal of flow can contribute to increased venous hypertension which promotes a continuous cycle of structural damage to the vein. Since the saphenous vein is a relatively superficial vein, it is often the vein that is visibly distended and problematic for the patient. [28]

Questions

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Figure

Saphenous neurovasculature. Image courtesy S Bhimji MD

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