Blood supply to the femoral head

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The normal vascular anatomy of the femoral head in adult man

J. Trueta and M.H.M. Harrison  Oxford, England 1953

This study was undertaken to research the vascular changes accompanying osteoarthritis of the hip joint.

The study was concentrating on description of vessels from where they are about to enter the bone.
History: Palletta (1820), Cooper (1823), Sappey (1869) and Langer (1876).

They studied vessels bringing blood into the upper end of the femur.

From 1904-1950, the finer vessels within the bone of the femur were investigated.
Materials and methods

Human specimens obtained after death
36 specimens
2  20-30
2  31-40
1  41-50
1  51-60
12  61-70
11  71-80
5  81-90
2  91-100
From these specimens 15 injections were studied
Materials and methods

**Vessels injected**

Medial femoral circumflex artery
Common iliac
Common femoral

Vessels were studied by microscope and radiological analysis
Results

Vascular patterns established during the phase of growth persist throughout life.

The epiphysis and metaphysis receive their blood supply from separate sources.
Results

Vessels were named in accordance with their destinations and referenced to the site of entry to bone.

Epiphysial arteries named medial and lateral.

Metaphysial arteries named superior and inferior.
Results

The lateral Epiphysial and both Metaphysial arteries usually arise from the medial femoral circumflex artery.

The medial Epiphysial is a continuation of the artery within the ligamentum teres which comes from the acetabular branch of the obturator artery.
Results

Lateral Epiphysial arteries predominate in the epiphysis
Supplied 4/5 of the epiphysis in 7 specimens
Supplied 2/3 of the epiphysis in 7 specimens
Supplied more than 1/2 in 1 specimen
Results

The inferior Metaphysial arteries were found to supply 2/3 of the Metaphysial tissue. These proportions represent the more usual arrangement and must be subject to considerable variation.
The lateral Epiphysial arteries

Enter the head superiorly and posero-superiorly

2-6 in number

Spiral for a short distance when they enter bone

Lie within a thick fibrous sheath

They follow the line of growth plate they run downwards, medially and anteriorly
The medial Epiphysial artery

Its main branch runs laterally on the same level as the fovea capitis
The branch meet and anastomose with the main lateral Epiphysial vessels
The length of the course is proportional to size
Epiphysial vessels

The direction of distribution of these branches is into the epiphysis and towards the joint surface.

The outflow to the metaphysis from these vessels is small.
Superior Metaphysial arteries

2, 3, or 4 vessels

Enter the superior aspect of the femoral neck some distance from the margin of the articular cartilage

Give origin to the lateral Epiphysial group

They supply the site previously occupied by the Epiphysial plate
Inferior Metaphysial arteries

Frequently one vessel
Enter bone close to the inferior margin of the articular cartilage
The largest vessel in these groups
Run up towards the epiphysis
Anastomoses

There is a free anastomosis inside both the epiphysis and the metaphysis.

There is anastomosis between the vessels of the two territories at the site previously occupied by the growth plate.

No evidence of the nutrient artery of the femur extending its area of supply up to the Metaphysial region as has been so frequently stated.
Changes with age

Ages from 20 -100 were studied no change in vascular pattern was noticed
Arterioles of marrow

There arrangement depends on the type of marrow

Red marrow is restricted to 2 areas the metaphysis and a zone of epiphysis underlying the articular cartilage and the fovea capitis

Yellow marrow occupy most of the epiphysis

A sharp line of demarcation is seen between these 2 areas

Yellow marrow have capillaries while red marrow have sinusoids
Arterioles of marrow

Microscopically there is no clear cut separation of the marrow into red and yellow. The 2 merge gradually from very cellular to the completely fatty. Circulation in this area is by small capillaries and sinusoids.
Articular cartilage

Normal articular cartilage is avascular. Come into contact with capillary vessels in 2 situations:

- *On deep attached surface*
- *Peripheral margin*
Clinical importance

Higher incidence of AVN with fractures disrupting the lateral Epiphysial arteries
The normal vascular anatomy of the human femoral head during growth

Joseph Trueta, Oxford, England 1953

An attempt to explain the evolution of the vasculature of the head and neck of the human femur from the last 4 weeks of fetal life up to the fusion of the upper epiphysis at age of 17
Material and methods

Human specimens after death
Same injecting method as used in previous paper
46 specimens 21 males 25 females
23 from 3 weeks fetal life to 3 years
10 from 3 to 6 years
1 from 6 to 9 years
12 from from 9 to 17
Vascular arrangement at birth

Vascular pattern at this stage is most constant.

Vessels coming from lateral of the head proceed horizontally towards its medial side.

Other vessels emerge almost vertically from the top of the ossified shaft.

Vessels are seen coming from the round ligament but they are not constant.
Vascular arrangement from 4 months to 4 years

Predominant blood flow arises from the Metaphysial vessels crossing the area later to be occupied by the growth plate.

Lateral Epiphysial vessels are also important at this phase.

There is no penetrating vessels coming from the ligamentum teres even if in early days some large vessels are seen they soon disappear.
From 4 to 7

The Epiphysial plate has established a firm barrier between epiphysis and metaphysis.

The Metaphysial blood flow decreases to become negligible.

Round ligament has not yet provided vessels that penetrate the epiphysis.

At this stage the only blood supply comes from the lateral Epiphysial vessels.

All tightly grouped on the lateral aspect of the head.
Preadolescent

Growth plate acts as a closed barrier to the vessels.
The arteries from the ligamentum teres finally reach the depth of the epiphysis and become anastomosed to other vessels of the lateral Epiphysial arteries.
At this stage the epiphysis receives blood from 2 main sources.
Here the barrier of the Epiphysial plate begins to break down and vascular anastomosis cross over
Clinical importance

1-3 years of age the delay in appearance of the ossification center in DDH because the lateral Epiphysial vessels are occluded by the capsular pull.

4-7 years Legg-Perthes’ disease the only blood supply at this age is the lateral Epiphysial which may be abstracted by trauma or inflammation.

11-15 years slipped epiphysis great vascular activity in the Metaphysial side of growth plate preceding the fusion of the epiphysis.
Changing patterns of proximal femoral vascularity

By John A. Ogden

Yale university school of medicine
1974
36 hips
Age range from 7 months of gestation to 3 years of age
Causes of death not related to MSK system
8 injected via the abdominal aorta
10 hips from fetal cadavers ages from 7 to newborn were injected by umbilical artery
The remaining of the hips were initially dissected and the course of blood vessels towards the hip with relation the soft tissue and muscles were studied
Results

Proximal part of the femur blood supply comes from Deep femoral (profunda) Gives 2 branches Lateral and medial circumflex arteries Both came from the deep femoral except in 3 cases which the medial circumflex took origin from the common femoral artery The origin was at the level of tendinous portion of the iliopsoas muscle
Lateral circumflex artery

Ascending and descending branches supply adjacent muscles

Transverse branch inters near the insertion of the capsule into the anterior intertrochanteric notch

The lateral circumflex supplies the antrolateral growth plate, the majority of the greater trochanter and the anteromedial femoral head
Medial circumflex artery

- Anteromedial growth plate
- Posteromedial chondroepiphysis
- Posterior growth plate
- Posterior greater trochanter
Artery of the ligamentum teres

This vessel arose from the medial circumflex artery in 5 cases but in 23 cases it arose from the obtuators artery.

Small medial area of the femoral head.
Blood supply of the femoral head is derived from 2 vascular systems the posterosuperior and the posterioinferior. From multiple small vessel supply at birth these two vascular system evolve over 18-24 months. These are from the medial circumflex artery.
Discussion

The Metaphysial arteries enter the metaphysis directly along the anterior and posterior capsular insertions with few branches intra-articularly. These arteries are from the lateral circumflex artery. In this study it showed that there are numerous vessels arteriosinusoidal in appearance crossing the growth plate. As the ossification center formed in the epophysis there was reduction of the number of vessels crossing the growth plate.
Along the intertrochanteric notch the blood vessels both veins and arteries are external to the joint capsule.

A few small branches coursed within the capsule but these small vessels had no role in the blood supply of the femur.
Clinical importance

Capsulotomy per se will not affect the blood supply of the proximal part of the femur as long as the underlying and anatomically separate posterosuperior and posteroinferior vessels are not damaged and as long as the capsular incision is not carried down to the intertrochanteric notch.
Clinical importance

During the transition phase from multiple to limited vessel supply, the capital femoral epiphysis is quite susceptible to vascular compromise.

Compromise of the medial circumflex artery may occur between:

1. Acetabular labrum and the intertrochanteric groove
2. Iliopsoas tendon and the adductor longus muscle
3. Iliopsoas tendon and the pubic ramus
The arterial supply of the developing proximal end of the human femur

Stanley M. K. Chung, MD
Philadelphia, Pennsylvania
1976
Materials and methods

235 hips from 147 autopsied fetuses and children
Satisfactory perfusions were obtained on 150 specimens
109 white
38 black
102 males
48 females
Age from 26 weeks gestation to 14 years
The extracapsular arterial ring

The medial and lateral circumflex arteries are the primary arteries. They form extracapsular ring surrounding the base of the femoral neck.

The medial, posterior and lateral parts of this ring were continuation of the medial circumflex artery.

The anterior portion of the ring is from the lateral circumflex artery.
Medial femoral circumflex

Deferent origins from the femoral artery or from profunda artery.

The artery passed in posterior direction in the interval between the iliopsoas and the pectineus muscle and then between the medial capsule and the obturator externus muscle.

Branches which traversed the capsule progressed subsynovilly up to the femoral neck.

In adults the termination of the medial circumflex artery provided most of the arterial supply to the femoral head, neck and trochanter.
Lateral femoral circumflex artery

Mostly from profunda artery
It ran laterally, anterior to the iliopsoas and dividing into several terminal branches
The ascending branch ran laterally and superiorly and was the source of the anterior ascending cervical branches to femoral head and neck
Ascending cervical arteries

Anterior from lateral circumflex
Posterior from medial circumflex
These arteries are traversing the capsule
The lateral ascending which is from lateral circumflex artery supplies the greatest volume of femoral head and neck
The capsule in the trochanteric fossa at the site that the lateral ascending artery cross was very narrow especially in less than 8 years and was noticed to have more space in the older specimens because of longer neck
Intra-osseous arterial supply

Originates from ascending cervical vessels.

These vessels branch into short ascending arteries that penetrate the bone and terminate in the metaphysis whereas the long ascending arteries extend upward to supply the secondary center of ossification.
Barrier between epiphysis and metaphysis

The epiphysial plate constituted an absolute barrier to blood flow between the epiphysis and metaphysis.

However, the epiphyseal and metaphyseal branches of the ascending cervical arteries supplied both areas, therefore there is anastomosis between the epiphyseal and the metaphyseal arteries on the bone but not within the bone.
The artery was filled in 113 of 123 specimens
10 specimens no artery seen
78 specimens the artery only in the ligament
20 specimens provided 1 deep vessel to the center of the head
15 specimens 2 or more vessels to center of the head seen
conclusion

2 collateral arterial rings supply the femoral head and neck
One ring is extracapsular the other is subsynovial and intra-articular
The intra-articular was more often incomplete in specimens from males than in females
extracapsular arterial ring
at the base of the femoral neck
Formed posteriorly by large branch of MFCA
Formed anteriorly by smaller branches of LFCA
The superior & inferior gluteal artery have minor contributions
What do you need to know

Epiphyseal blood supply arises primarily from lateral epiphyseal vessels that enter head posterosuperiorly and vessels from medial epiphyseal artery entering thru ligamentum teres

Epiphyseal arterial branches arise as arteries of subsynovial intraarticular ring
What do you need to know

metaphyseal blood supply:
arises from extracapsular arterial ring

• ascending cervical arteries
• subsynovial
Medial circumflex artery
arises from posteromedial aspect of deep femoral artery or sometimes from femoral artery
supplies majority of blood supply to femoral head;
Branches of MFCA enter capsule of hip joint near its distal insertion and course proximally along femoral neck toward femoral head
Lateral circumflex artery usually arises from lateral side of deep femoral artery. Lateral circumflex of femoral artery is principal source of blood to the trochanteric area & inferior part of femoral neck. It anastomoses to limited degree with branches of medial circumflex and nutrient artery of femur sends branches to metaphysis or neck but does not contribute significantly to head.
What do you need to know

Artery of ligamentum teres

Derived from **obturator**

inadequate to supply femoral head with displaced fractures

forms the medial epiphyseal vessels only

small & variable amount of the femoral head is nourished by artery of ligamentum teres
What do you need to know

Ascending cervical branches
Arise from the extracapsular ring
These give rise to retinacular arteries
gives rise to subsynovial intra articular ring
anteriorly, they penetrate capsule of hip joint intertrochanteric line
posteriorly, they pass beneath the orbicular fibers of capsule
- ascending cervical branches may be divided into 4 branches
  - anterioal, medial, lateral, posterior;
  - of these lateral provides most of blood supply to femoral head