SYNOVIAL FLUID: An Overview

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PBL SEMINAR MBBS III

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• Normal joint is surrounded by a membrane:
  • Synovial membrane (or Synovium) that forms a capsule around the end of the bone;
• Synovial membrane secretes a liquid:
  • Synovial fluid (Synovial: “like egg white”);
What are the functions of Synovial Fluid?

• Several important functions: It serves as:
  • Lubricant,
  • Shock absorber,
  • Nutrient carrier
As a lubricant:

• In healthy joins (healthy cartilage tissue) **Synovial fluid** makes joint slicker than wet ice;

**NB:**

• Synovial fluid cannot function as a lubricant in joints with poor cartilage caused by inadequate production of **Glucosamine and Chondroitin sulfate** which are the building blocks of cartilage;

• Synovial fluid becomes thin and watery, thus cannot function as a lubricant;
As a shock absorber or hydraulic fluid

- Synovial fluid in contact with cartilage in joints protects the bones from the tremendous impact they would receive when we:
  - Walk Run,
  - Jump,
  - Skip, etc,

- Synovial fluid is a **Dilatent liquid**;
- Synovial fluid has dilatent properties;
What are the characteristics of a Dilatent liquid?

• Dilatent liquids are characterized by the rare quality of becoming thicker and more viscous, when shear (force) is applied to them;
What are the Dilatent properties of Synovial Fluid?

• Synovial fluid in Knees and Hips becomes very viscous at the moment of shear in order to protect the joints; then it thins out again to its normal viscosity instantaneously to resume its lubricating function between shocks;

• Change of state of Synovial fluid occurs over and over again, very rapidly, during vigorous exercise:
  • Sports,
  • Dancing,
  • Walking,
  • Jumping,
  • Skipping, etc;
• This mechanism breaks down, when adequate amount of Glucosamine and Chondroitin (building blocks of cartilage) are not synthesized in the body;
  • Viscosity is reduced, giving thin, watery synovial fluid that fails to function as shock absorber and lubricant;
• Resultant effect is:
  • Pain,
  • Stiffness,
  • Decreased mobility,
• These characterize Osteoarthritis:
  • A condition primarily due to imbalance between rate of destruction and rate of production of cartilage;
Summarise the basic functions of Synovial Fluid

• Lubrication to reduce frictional resistance to joint movement;
• Provide nutrition to articular cartilage;
• Protect the joint structures when subjected to large compressive forces;
• Provide a liquid environment within a narrow pH range;
• Remove various products of metabolism;
State the general composition of Synovial Fluid

- It is a highly viscous fluid that is a Transudate of plasma;
  - Dialysate of blood plasma filtered through semi-permeable walls of blood vessels, with addition of **Hyaluronic Acid**;
  - Hyaluronic acid is one of the high molecular weight compounds called **Glycosaminoglycan (GAG)** produced by synovial cells;
- Hyaluronic acid makes Synovial fluid viscous
• **Synovial fluid:**
  • Is clear, almost colorless or straw-colored;
  • Has about one-third the amount of protein in blood plasma;
  • Contains only low molecular weight proteins such as Albumin;
  • Does not contain high molecular weight proteins such as Fibrinogen therefore it *does not form Fibrin Clot* when aspirated;
  • Has low Glucose content
What is Hyaluronic Acid?

• Hyaluronic acid:
  • Consist of repeating Disaccharide units of N-Acetylglucosamine and Glucuronic acid;
  • Is a Glycosaminoglycan (GAG) in synovial fluid and cartilage;
  • Is synthesized in synovial membrane and released in synovial fluid;

• Large molecular weight, poly-electrolyte-character, and large volume of water it occupies in solution contribute to the properties of Hyaluronic acid as lubricant and shock absorbent;
State some functions of Hyaluronic acid?

• It acts as lubricant and shock absorber;
• It acts as barrier permitting metabolites to pass through it by diffusion but resist penetration by bacteria and other infectious agents;
• Amount of Hyaluronic acid in cartilage varies, but it is less than 1% of total Glycosaminoglycans (GAG);
• It can be present in a free state, but it is usually found as a part of Proteoglycan aggregates in cartilage;
What are GAG (MUCOPOLYSACCHARIDES)?

• GAG are un-branched Hetero-polysaccharides made up of repeating disaccharide units in which one component is always:
  • *Amino sugar* (D-Glucosamine or D-Galactosamine);
  • The other component is usually **Uronic Acid**;
List the different types of GAG?

• Seven types of GAG:
  • Hyaluronic Acid,
  • Chondroitin Sulfate (made up of Chondroitin 4-sulfate and Chondroitin 6-sulfate),
  • Keratan Sulfate I & II,
  • Heparin,
  • Heparan Sulfate,
  • Dermatan Sulfate,
What are Proteoglycans?

• PROTEOGLYCANS are the complex structures formed when GAG are covalently linked to proteins

• GAG are Polysaccharide portions of Proteoglycans
Outline the general structure of Proteoglycans?

- Proteoglycan is a macromolecule made up of protein core to which many GAG chains are attached;
- Proteoglycan consist of 10% protein and 90% GAG;
- Hyaluronic acid is non-covalently bound to Proteoglycan aggregate;
- Glycoproteins stabilize non-covalent association of Proteoglycan subunits with Hyaluronic acids in aggregate;
- In Osteoarthritis there is a characteristic reduction in aggregating Proteoglycans;
What is the general composition of Articular Cartilage?

- Articular cartilage is elastic, fluid-filled, and backed by a relatively impervious layer of calcified cartilage and bone;
- About 80% of this specialized Hyaline cartilage is liquid (two-thirds are in the matrix);
- Collagen forms about half to two-third of the dry weight of cartilage;
- Chondroitin Sulfate (GAG) is in the matrix and comprises one-sixth to one-fourth of the dry weight of articular cartilage;
- Cartilage must remain resilient to act as shock absorber;
• To retain minimal friction cartilage must maintain a smooth and unbroken surface;
• If changes occur in surface, friction increases and a vicious cycle of wear and cartilage destruction ensures;
• Diffusion of nutrients from synovial fluid into articular cartilage is enhanced by the cyclic “kneading” of the cartilage in normal activity;
• Interference with the supply of nutrients may contribute to degenerative joint disease;
Osteoarthritic knees

- Usually contains Synovial fluid with:
  - Increased cell numbers,
  - Increased levels of enzymes,
  - Greater number of particles than normal knee,
List some changes in composition of Synovial fluid in Arthritis?

• Increased protein content;
• Increased number of cells;
• Possible changes in Hyaluronic acid structure;
• In various types of Arthritis, Proteoglycans may act as auto-antigens, thus contributing to the pathologic features of these conditions;
• Amount of Chondroitin sulfate in cartilage diminishes with age, but the amounts of Hyaluronic acid and Keratan sulfate increase;
• These changes may contribute to development of Osteoarthritis;