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ROLES OF LABORATORY WORKERS IN ACCURACY OF SYNOVIAL FLUID ANALYSIS; REVIEW

Salwa Jameel Hakeem
Laboratory specialist, King Fahd general hospital, jeddah

Heba Mustafa Shaheen
Lab Specialist, King Fahd general hospital, jeddah

Maryam Mohammed Alkhamisi
Laboratory technician, King Fahd general hospital ,jeddah

Majidah Bakr Banaemah
Senior Specialist Laboratory, King Fahad General Hospital, Jeddah

Samah Mohammed Shaheen
Lab Specialist, King Fahd general hospital, jeddah

Gelan Jamil Khoja
Senior Laboratory Specialist, king Fahd General Hospital

Najlaa Abdulkader Basamad
Laboratory Speciallst, king Fahad general hospital, Jeddah

Abdullah Awadah Alrefaie
Head of virology lab, King fahad general hospital , Jeddah

Abstract:

The collection and analysis of synovial fluid in veterinary medicine was initially employed for diagnosing lameness and joint disorders in large animals. As knowledge and expertise in the medical, radiographic, and orthopedic fields have advanced, our emphasis in small animal arthrology and orthopedics has broadened from solely addressing fractures and cruciate repairs to encompassing the assessment of degenerative, immune-mediated, infectious, and non-inflammatory joint diseases. Laboratory procedures for small animal specimens were adjusted to suit the reduced sample quantities. Simultaneously, there has been a swift rise in the quantity of serologic tests for identifying infectious pathogens and immunological diseases. Veterinarians can now identify and manage an increasing array of joint illnesses from these origins. Laboratory examination of synovial fluid (SF) is a crucial component in the diagnostic assessment of patients with joint disorders. Laboratory analysis of SF can yield critical insights for diagnosis, contribute to patient monitoring and treatment, and ultimately enhance the patient's health and quality of life. Laboratory examination of synovial fluid is hardly conducted in Croatian medical biochemistry facilities. As a result, protocols for SF laboratory testing lack adequate harmonization.

Intriduction:

Synovial fluid is characterized as the accumulation of fluid contained within a joint cavity. Synovial fluid is physiological, serving as a lubricant for articular cartilage within the joint space and providing nutrients via diffusion to adjacent structures such as cartilage, meniscus, and labrum. Synovial fluid is generated as an ultrafiltrate of blood plasma and predominantly consists of hyaluronan, lubricin, proteinases, collagenases, and prostaglandins [1]. Synovial fluid is produced by fibroblast-like type B synovial cells. Physiological alterations in synovial fluid volume and composition arise due to trauma, inflammation, and the invasion of bacteria, fungi, or viruses. In cases where patients exhibit intensely painful joints with potential infection, inflammation, or non-inflammatory effusion, synovial fluid aspiration and analysis are essential for diagnosis and treatment direction [2].

The development of aberrant synovial effusions is analogous, regardless of whether it is induced by cartilage destruction in degenerative joint disease or by synovitis in immune-mediated arthritis, with distinctions only in the nature and intensity of the cellular infiltrate and joint damage. In reaction to an injury, chondrocytes and synoviocytes secrete cytokines, resulting in dilatation of the subsynovial capillaries, which enhances vascular permeability and facilitates the extravasation of fluid, proteins, and inflammatory cells into the joint area. The recently arrived leukocytes facilitate additional inflammatory alterations and induce the secretion of degradative enzymes from many cell types. The type and quantity of leukocytes that infiltrate the synovium and enter the synovial fluid determine the cellular constituents of the joint effusion and the clinical manifestations of arthritis [3].

Degenerative joint disease exemplifies a noninflammatory arthritis. Additional illnesses that may exhibit noninflammatory synovial fluid include traumatic joint disorders, hemarthrosis, neoplastic abnormalities affecting the joint area, and arthropathies linked to viral infections in felines. Despite being categorized as noninflammatory, these illnesses frequently exhibit a low-grade mononuclear inflammatory response in the synovium [4].

Review:

Arthrocentesis can facilitate diagnosis in cases of joint effusion, unexplained joint discomfort, or suspected intra-articular infection. In scenarios where intra-articular injection is contemplated, aspiration must precede administration, since the aspirated fluid should be examined for any apparent abnormalities or indications of significant infection. Arthrocentesis may be used therapeutically to alleviate discomfort in a joint where an effusion or hemarthrosis restricts the entire range of motion. Aspiration must be conducted by a qualified physician following sterile procedural protocols to limit the risk of infection and contamination of the aspirate [5]. Indications for synovial fluid aspiration and analysis encompass the occurrence of an acutely painful joint accompanied by warmth or erythema, suspicion of septic arthritis, suspicion of subacute or chronic periprosthetic joint infection, acute exacerbation of chronic knee pain due to osteoarthritis or non-inflammatory arthritis, or acute trauma resulting in painful effusion. In the clinical manifestation of acute damage, arthrocentesis of hemarthrosis can frequently be therapeutic and offer substantial pain alleviation in the acutely traumatized knee. Effusions resulting from chronic inflammatory arthritis may be subjected to therapeutic aspiration for analgesic purposes. A conclusive diagnosis of gout or pseudogout also warrants aspiration.

Infection and gout can coexist within a joint area. Effusions of indeterminate origin necessitate aspiration and investigation [5].

Multiple variables may impede aspiration and hence the examination of synovial fluid. Unsuccessful aspiration frequently occurs due to synovial obstruction of the needle, hindering sample collection. The use of non-sterile method may result in contamination of the collected fluid. It is essential to acknowledge that various etiologies may coexist; the existence of gout does not preclude the possibility of a concurrent infection. Complications arising directly from arthrocentesis are infrequent, and when they do occur, they are generally not serious. Possible risks encompass: the introduction of a cutaneous infection into the joint, infrequent cartilage injury from needle insertion, pain at the arthrocentesis site or localized ecchymosis, hemorrhage and iatrogenic hemarthrosis, and skin reactions to antiseptics or adhesive from soft bandages. The predominant problem documented is the reaccumulation of joint effusion [6].
Arthrocentesis and joint fluid analysis are essential for the clinical assessment of both primary joint illnesses and systemic diseases that present with joint effusion. The procedure of arthrocentesis to obtain synovial fluid for analysis is not more challenging nor riskier than pleurocentesis or abdominocentesis. Analysis of synovial fluid is advised in conditions marked by prolonged or intermittent fever of unclear origin, changing limb lameness, or generalized malaise when arthralgia is suspected. Typically, joints with extra fluid should be sampled; however, if such joints are absent, a minimum of two to three joints should be examined, particularly the carpal and tarsal joints [7]. All instances of persistent lameness and those refractory to nonsteroidal anti-inflammatory medications should undergo synovial fluid analysis to exclude a chronic infectious condition [5]. Arthrocentesis and analysis of synovial fluid can verify arthritis, classify the response as inflammatory or noninflammatory, and, in certain cases, identify the etiological culprit.

Although arthrocentesis is generally well accepted with few complications, gaining informed permission is essential prior to the treatment. The procedure's details, associated risks and benefits, potential consequences, and alternative therapies or diagnoses must be elucidated. Patients must comprehend and articulate the indications for their procedure, as well as be acquainted with the previously addressed complications. Patients must be afforded the opportunity to pose inquiries, which should be addressed by the attending physician. To ensure patient safety, the previously described sterile procedural procedure must be employed consistently to reduce the risk of infection. The patient's file must be meticulously examined before arthrocentesis to confirm the absence of serious allergies to any medications, materials, or chemicals that may be utilized during the surgery.
The laboratory analysis of synovial fluid encompasses an assessment of physical properties, chemical analyses, cell quantification, and differential cell counts. Microbial cultures for infectious agents or serological tests for infectious or immunological illnesses may be warranted in some instances. The history, presentation, radiographic findings, and volume of fluid collected dictate the selection of tests to be conducted.

The collecting procedure may influence the results and interpretation of synovial fluid analysis. Inadvertent entry of a blood artery might cause hemodilution of the specimen, hence affecting the total nucleated cell counts (TNCCs) and differential cell count. A crucial initial step in arthrocentesis is the identification of anatomical markers surrounding the affected joint [8]. Upon

obtaining a sufficient sample volume, an aliquot should be transferred to a pediatric EDTA tube, as fluid from aberrant joints is more prone to coagulation. Fluid samples for cell counts and cytological evaluation may be refrigerated for 24 hours; however, rapid slide preparation is preferable [9]. When just a little quantity of fluid is obtained, it is well acknowledged that the creation of stained slides for microscopic examination yields the most valuable insights for the diagnostic procedure [9].

The assessment of physical characteristics entails a visual inspection of hue, turbidity, viscosity, and volume. Normal synovial fluid in dogs and cats is transparent, colorless, viscous, devoid of flocculent material, and does not coagulate. Volume is typically assessed subjectively rather than quantitatively, as joint aspiration in the majority of dogs or cats produces less than 0.1 to 0.25 mL. Joint disease may be associated with alterations in synovial fluid volume, either an increase or a reduction. Elevated volume is typically observed during the physical examination as joint distension. An arid or almost arid joint tap typically signifies diminished volume.

Synovial fluid from healthy joints does not coagulate in a tube or syringe but tends to produce a gel-like consistency. It is crucial to distinguish gel formation from clotting. Stirring the gel induces the material to revert to its liquid condition. The reversible production of a fluid-gel is referred to as thixotropism.

The typical viscosity of synovial fluid is determined by the concentration and polymerization of hyaluronic acid, a glycoprotein. Viscosity serves as a measure of the fluid's lubricating characteristics within the joint, and a reduction in viscosity may result from several sources. The content of hyaluronic acid may diminish due to diminished synthesis from synovial membrane injury, dilution from plasma or fluid input, or breakdown by leukocytes or bacteria. Intra-articular medication injection or joint lavage can decrease fluid viscosity.

Provided there is sufficient sample volume, quantifying cells per microliter of fluid is beneficial and can serve as a crucial differentiator in the diagnostic procedure. Total nucleated cell counts (TNCCs) are crucial for distinguishing between inflammatory and non-inflammatory arthropathies, as well as for identifying the different etiologies of inflammatory arthritis. Most laboratories choose a reference value of fewer than 3000 cells per milliliter for the total nucleated cell count (TNCC) [10]. Sequential TNCC measurements in synovial fluid are valuable for monitoring treatment efficacy in a specific joint. Red blood cell (RBC) counts yield minimal pertinent information.

TNCC can be quantified using manual techniques with a hemacytometer or via electronic cell counters. The viscosity and hyaluronic acid concentration of synovial fluid can negatively impact both techniques. The standard dilution fluid employed for white blood cell (WBC) counts in blood is unsuitable for synovial fluid due to its propensity to induce acid precipitation of hyaluronic acid. The viscosity properties of several synovial fluid samples lead to mistakes in the pipetting and dilution processes in both methods. WBC counts produced by electronic counters typically exceed those obtained using manual methods; however, the discrepancy is insufficient to affect interpretation. Numerous investigations have demonstrated that incorporating hyaluronidase into the fluid prior to counting enhances the reliability of TNCC counts and elevates the quality of smears [11].

Synovial fluid smears might be prepared utilizing the identical methodologies applied for blood or cavity fluids. Fluid viscosity may pose challenges that impact slide quality. The presence of

hyaluronic acid in normal or noninflammatory effusions results in a pink background staining that is fine to coarsely granular and features numerous crescents or folds [12]. The background material renders numerous nucleated cells diminutive, intensely pigmented, and challenging to identify. Neutrophils can become sufficiently rounded and black to be indistinguishable from lymphocytes. The peripheries of the smear are the optimal locations to locate identifiable cells. In samples exhibiting elevated cell counts and normal viscosity, the nucleated cells arrange in rows. For viscous fluids, the spreader slide should be maintained at a shallow angle to distribute the fluid across an extensive region [13].

Concluion:

Synovial fluid aspiration and analysis is an essential therapeutic and diagnostic treatment that alleviates pain from joint effusion and aids in diagnosing potentially significant joint diseases. It is an economical, very efficient method for pain alleviation and diagnosis, capable of being executed swiftly, without general anesthesia, at the bedside. Arthrocentesis does not necessitate a specialized surgeon, hence enhancing its efficacy in timely treatment and diagnosis. In synovial fluids with diminished glycoprotein or hyaluronic acid levels, the dense pink granular background staining is diminished or may be absent. Consequently, microscopic evaluation consistently encompasses an analysis of the background's granularity and staining intensity, as these factors serve as indicators of glycoprotein or hyaluronic acid content. Red blood cells are few in normal synovial fluid. Increased quantities of joint trauma, inflammation-related bleeding, or hemorrhage resulting from arthrocentesis should be taken into account. In the latter case, platelets are typically observed amid the red blood cells. In cases with chronic or resolving joint bleeding, macrophages engulf red blood cells and deposit hemoglobin degradation products, manifesting as blue-black coarse intracytoplasmic granules. Nucleated cells commonly identified in synovial fluid including neutrophils, lymphocytes, monocytes, and macrophages. These cells are observed in fluids from both healthy and pathological joints. With experience, the density of nucleated cells on stained slides can be utilized to classify the TNCC as normal, elevated, or significantly elevated.

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