



Pericardiocentesis in Clinical Practice: Indications, Technique, Patient Safety Considerations, and Nursing Roles

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Abstract

Background: Pericardiocentesis is a critical cardiovascular intervention for evacuating pericardial fluid, primarily indicated in cardiac tamponade and large symptomatic effusions. It serves both therapeutic and diagnostic purposes, reducing intrapericardial pressure and enabling etiologic clarification.

Aim: To review the indications, anatomical considerations, procedural techniques, and safety measures associated with pericardiocentesis, emphasizing contemporary image-guided standards.

Methods: This narrative synthesis integrates current clinical guidelines and evidence-based practices regarding pericardiocentesis. It examines anatomical relationships, physiologic principles, procedural preparation, technical approaches, and complication management strategies.

Results: Modern practice prioritizes echocardiography-guided pericardiocentesis for enhanced accuracy and reduced risk. Indications include cardiac tamponade, large symptomatic effusions, purulent pericarditis, recurrent effusions, and traumatic hemopericardium. Contraindications are largely relative outside emergent settings, with coagulopathy and unclear diagnosis being key concerns. Complications—such as myocardial laceration, vascular injury, pneumothorax, arrhythmias, and infection—occur in approximately 5% of cases but are mitigated by imaging guidance, structured preparation, and surgical backup. Interprofessional collaboration significantly improves outcomes.

Conclusion: Pericardiocentesis remains a life-saving procedure in acute cardiac care. Image-guided techniques, meticulous planning, and team-based execution are essential to optimize safety and efficacy.

Keywords: Pericardiocentesis, cardiac tamponade, pericardial effusion, echocardiography-guided drainage, cardiovascular emergency, interprofessional care

Introduction

Pericardiocentesis is an invasive cardiovascular procedure performed to aspirate fluid from the pericardial space for immediate therapeutic decompression and/or diagnostic evaluation. Clinically, it occupies a pivotal role in the emergency management of significant pericardial effusions, particularly when intrapericardial fluid accumulation compromises cardiac filling and precipitates hemodynamic instability. In this context, pericardiocentesis is most frequently undertaken to treat cardiac tamponade, a rapidly progressive and

potentially fatal syndrome characterized by impaired ventricular diastolic filling, reduced stroke volume, and ultimately obstructive shock if not promptly reversed.^{[1][2]} Beyond frank tamponade, pericardiocentesis may also be indicated in selected acute or chronic effusions that produce substantial cardiopulmonary symptoms—such as dyspnea, orthopnea, and peripheral edema—or when sampling of pericardial fluid is required to clarify the underlying etiology and guide definitive management.^{[1][2]} The decision to proceed with pericardial drainage is grounded in an integrated assessment of clinical

severity, imaging findings, and suspected cause. Pericardial fluid may accumulate when production increases, when lymphatic or venous drainage becomes impaired, or when both mechanisms coexist, resulting in a net rise in pericardial volume and pressure. Etiologic considerations are broad and include infectious processes, malignancy-related serositis, autoimmune and inflammatory diseases, post-myocardial infarction or postprocedural syndromes, and metabolic derangements such as uremia.[1][2] Importantly, the physiological impact of an effusion depends not only on its absolute size but also on the rate of accumulation and the compliance of the pericardium; even a moderate volume may produce tamponade physiology if it develops rapidly, whereas large chronic effusions may be partially accommodated until a critical pressure threshold is reached. Once intrapericardial pressure exceeds intracardiac filling pressures, chamber collapse and reduced preload ensue, creating the clinical imperative for urgent decompression. Although pericardiocentesis has historically been performed using “blind” landmark-based techniques, contemporary standards emphasize real-time imaging guidance to enhance procedural accuracy and reduce iatrogenic harm.[3] Transthoracic echocardiography is commonly used to identify the optimal access site, confirm needle trajectory relative to the effusion, and monitor the immediate hemodynamic response to drainage, while fluoroscopy may be used in specific settings or when catheter-based drainage systems are deployed.[3] The choice of technique—blind versus image-guided—and the selection of an approach pathway are influenced by multiple factors, including the distribution and loculation of the effusion, patient stability, available expertise, and the presumed etiology.[2] Consequently, while pericardiocentesis is often highly effective and can be performed safely in experienced hands, it remains a high-risk intervention when undertaken without sufficient anatomical proficiency, meticulous planning, or appropriate imaging support. This underscores the need for structured procedural competence and interprofessional coordination to optimize outcomes in patients requiring pericardial fluid evacuation.[1][2]

Anatomy and Physiology

A comprehensive understanding of pericardial anatomy and the physiological consequences of pericardial fluid accumulation is foundational to safe and effective pericardiocentesis. Because the target space is small, dynamic, and surrounded by vital cardiopulmonary structures, clinicians must integrate three domains in real time: the layered architecture of the pericardium, the normal mechanical role of the pericardial sac in cardiac function, and the pathophysiologic cascade that occurs when the pressure–volume relationship of the pericardium is exceeded. In practice, this knowledge translates into procedural choices—such as selecting an access window, angling the needle trajectory, and

anticipating complications—that directly influence patient outcomes. From an anatomic standpoint, the pericardium is a double-layered enclosure that surrounds the heart and the proximal great vessels. It consists of an outer fibrous pericardium and an inner serous pericardium. The serous component is further divided into a parietal layer, which lines the internal surface of the fibrous pericardium, and a visceral layer (also termed the epicardium), which is tightly adherent to the surface of the myocardium. The visceral pericardium is composed predominantly of mesothelial cells and forms the biologically active interface with the heart. In contrast, the parietal pericardium is relatively collagen-rich and fibrous, forming a firm protective layer; its thickness is typically less than 2 mm, but its mechanical properties are disproportionately important because this layer largely determines the sac’s compliance. Between the visceral and parietal layers lies the pericardial cavity, a potential space that normally contains a small volume of lubricating fluid—commonly described as approximately 15 to 50 mL—functioning to reduce friction as the heart cycles through continuous motion within the thorax. This pericardial fluid is essentially a plasma ultrafiltrate, and under physiologic conditions it tends to collect preferentially along the interventricular and atrioventricular grooves. It drains through lymphatic pathways into nearby lymph nodes, providing an important route for maintaining fluid homeostasis within the pericardial space.[4]

The pericardium’s anatomic relationships explain both the feasibility and the risk profile of pericardiocentesis. The sac lies adjacent to the lungs and pleural reflections laterally, the diaphragm inferiorly, and the sternum and costal cartilages anteriorly. In addition, the phrenic nerves course along the pericardium, providing sensory innervation and mediating pain associated with pericardial irritation; their proximity is clinically relevant because inadvertent injury can lead to diaphragmatic dysfunction. Coronary arteries traverse the epicardial surface and thus are intimately related to the visceral pericardium, underscoring why uncontrolled needle advancement or an incorrect trajectory can result in catastrophic hemorrhagic complications. Consequently, “safe windows” for pericardial access are defined not merely by proximity to the effusion but also by the ability to avoid adjacent structures. Traditional landmarks described for pericardiocentesis include the left costoxiphoid angle and subxiphoid area, as well as parasternal regions, each representing a potential route to the pericardial space depending on fluid distribution and operator strategy.[4] A pericardial effusion—defined as an abnormal increase in fluid within this cavity—distorts these relationships, and although it may create a larger target space, it can simultaneously increase the likelihood of compressive physiology and procedural urgency. Physiologically, the pericardium serves several critical functions that support normal cardiopulmonary performance. It

provides mechanical protection to the heart, stabilizes cardiac position within the mediastinum, and limits acute chamber overdistension during sudden volume loading. By constraining excessive dilation, the pericardium helps preserve the efficiency of ventricular mechanics and contributes to the maintenance of optimal geometry for contraction. Additionally, the lubricating pericardial fluid allows smooth motion during systole and diastole, preventing frictional injury between the heart and surrounding structures. Under normal conditions, the small physiologic volume of pericardial fluid is compatible with unhindered filling and ejection, and intrapericardial pressure remains low enough that it does not impede venous return or ventricular compliance.

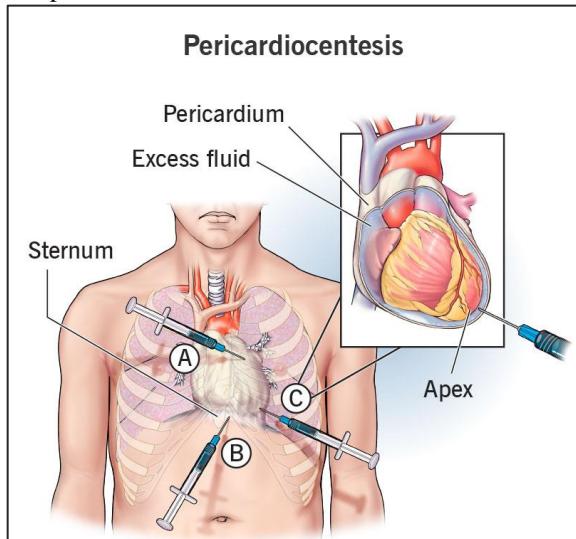


Fig. 1: Pericardiocentesis.

The key determinant of clinical deterioration in pericardial effusion is the pericardium's limited elasticity. The pericardial sac does have some capacity to accommodate increasing fluid volumes, but this capacity is highly dependent on the rate of accumulation. When fluid accumulates slowly, as can occur in chronic inflammatory states or malignancy-associated effusions, the pericardial tissues can gradually stretch and remodel. As a result, large volumes—sometimes described as up to 2 liters—may be present without immediate circulatory collapse. In these situations, the pericardial pressure–volume relationship shifts to the right, reflecting an adaptive increase in compliance that delays the point at which intrapericardial pressure rises steeply.^[4] The patient may still be symptomatic due to reduced cardiac reserve and impaired filling during exertion, but the compensatory “reserve” of pericardial distensibility buys time before overt tamponade occurs. In contrast, rapid fluid accumulation produces a markedly different physiological trajectory. When effusion develops acutely—such as with penetrating trauma, iatrogenic perforation, or ventricular wall rupture—the pericardium cannot stretch fast enough to accommodate the incoming volume. In this setting,

relatively modest volumes, often cited in the range of approximately 80 to 200 mL, can exceed the compliant range of the sac and trigger a rapid rise in intrapericardial pressure.^[4] Once the pressure–volume threshold is crossed, additional fluid causes disproportionate pressure increases, producing abrupt hemodynamic deterioration. This distinction is clinically decisive: an “intermediate-sized” effusion may be tolerated if chronic but may be immediately life-threatening if acute.

Pathophysiologically, pericardial effusion arises from an imbalance between fluid generation and clearance. Increased production may reflect pericardial inflammation (infectious or autoimmune), malignancy-related exudation, or postinjury bleeding. Decreased drainage can result from lymphatic obstruction, elevated systemic venous pressures, or infiltrative disease. Iatrogenic etiologies, including radiation-associated pericardial injury or chemotherapy-related inflammation, also contribute in selected populations. Regardless of cause, the clinical impact is governed by three interacting variables: total fluid volume, rate of accumulation, and pericardial compliance. Importantly, even small absolute volumes can result in tamponade when accumulation is rapid, while larger volumes may present with more indolent symptoms when accumulation is slow.^[4] Cardiac tamponade represents the end-stage hemodynamic consequence of a critically elevated intrapericardial pressure. As pericardial pressure rises, it begins to impede diastolic filling, reducing preload and thereby decreasing stroke volume and cardiac output. The low-pressure right-sided chambers are typically affected first, because the right atrium and right ventricle have thinner walls and lower filling pressures. Compression of these chambers limits venous return and amplifies ventricular interdependence, meaning that the filling of one ventricle occurs at the expense of the other within the fixed pericardial volume. During inspiration, intrathoracic pressure drops and venous return to the right heart increases; in tamponade, the right ventricle cannot expand outward due to pericardial constraint, so the interventricular septum shifts leftward, further restricting left ventricular filling. This exaggerated respiratory variation in ventricular filling underlies pulsus paradoxus, classically defined as a fall in systolic blood pressure greater than 10 mm Hg during inspiration, reflecting impaired left-sided preload and reduced systolic output. These physiologic features are not merely academic; they explain why tamponade can present with shock despite preserved contractility and why small changes in volume can produce dramatic changes in clinical status.

Pericardiocentesis interrupts this pathophysiologic spiral by reducing intrapericardial pressure, restoring the pressure gradient required for normal chamber filling, and allowing the heart to re-expand to an appropriate diastolic volume. As

pericardial constraint is relieved, ventricular interdependence normalizes, respiratory variation diminishes, and effective cardiac output improves. For clinicians, this is the core therapeutic logic: tamponade is fundamentally a mechanical problem, and pericardiocentesis provides a rapid mechanical solution. Nevertheless, because the procedure traverses anatomically crowded territory and targets a space whose size and location may vary with patient anatomy and effusion characteristics, mastery of pericardial anatomy and the dynamics of pericardial pressure–volume physiology is essential to perform pericardiocentesis safely and to recognize when urgent drainage is necessary to prevent irreversible hemodynamic collapse.[4]

Indications

Pericardiocentesis is principally indicated when pericardial fluid accumulation produces clinically meaningful symptoms or hemodynamic compromise, or when sampling of pericardial fluid is expected to clarify etiology and guide definitive therapy. In contemporary practice, the decision to proceed is not based solely on the absolute volume of effusion, but rather on the physiologic impact of the effusion (particularly evidence of tamponade), the suspected underlying cause, the anticipated trajectory (rapid progression versus chronic stability), and the feasibility of alternative diagnostic or therapeutic strategies. The core rationale remains consistent: evacuation of fluid decreases intrapericardial pressure, restores diastolic filling, improves cardiac output, and may provide diagnostically valuable fluid for microbiologic, cytologic, and biochemical analysis. The most urgent and widely accepted indication is cardiac tamponade. Tamponade represents a life-threatening state in which intrapericardial pressure rises sufficiently to restrict ventricular filling, causing obstructive shock that can rapidly progress to cardiac arrest if untreated. In this setting, pericardiocentesis is performed as an emergency intervention aimed at immediate hemodynamic stabilization. Clinically, tamponade is suspected when hypotension, tachycardia, elevated jugular venous pressure, pulsus paradoxus, and signs of poor perfusion occur in the context of a pericardial effusion, and it is commonly supported by echocardiographic findings such as right atrial or right ventricular diastolic collapse. Because tamponade physiology is fundamentally mechanical, drainage is often the fastest means of reversing circulatory failure. A second major indication is a large symptomatic pericardial effusion even in the absence of frank tamponade. Patients with sizable effusions may develop progressive dyspnea, orthopnea, chest discomfort, fatigue, or reduced exercise tolerance due to impaired cardiac filling and limited hemodynamic reserve. In these cases, pericardiocentesis is performed to alleviate symptoms, prevent clinical deterioration, and, when appropriate, obtain fluid for diagnostic evaluation. Notably, the same effusion volume may be tolerated differently

among patients depending on baseline cardiac function, intravascular volume, and pericardial compliance; therefore, symptom burden and physiologic assessment are central to decision-making [4].

Purulent pericarditis constitutes another critical indication. When bacterial infection of the pericardial space is suspected, urgent drainage is recommended to reduce bacterial load, relieve pressure effects, and facilitate targeted antimicrobial therapy based on culture and sensitivity testing. Purulent fluid is typically thick and loculated, and drainage may require catheter placement, repeated aspiration, or escalation to surgical drainage if percutaneous removal is incomplete. Early recognition and prompt evacuation are essential, as purulent pericarditis carries substantial morbidity and mortality when inadequately treated. Pericardiocentesis may also be indicated in postpericardiotomy syndrome following cardiac surgery, particularly when inflammation leads to clinically significant effusion with symptoms or hemodynamic compromise. In this setting, drainage can provide symptomatic relief and may help prevent progression to tamponade, while allowing clinicians to exclude other postoperative complications such as hemorrhagic effusion or infection. Similarly, recurrent pericardial effusion—whether related to malignancy, inflammatory disease, or idiopathic etiologies—often prompts pericardiocentesis when the recurrence is symptomatic, rapidly reaccumulating, or associated with worsening physiology. Recurrent effusions may require extended catheter drainage, intrapericardial therapies in selected cases, or referral for definitive procedures (e.g., pericardial window) when repeated percutaneous drainage is not durable [5].

Traumatic hemopericardium is a particularly time-sensitive indication that occupies a distinct place in emergency and trauma care. Blunt or penetrating chest trauma can result in bleeding into the pericardial space, producing hemopericardium and, frequently, tamponade physiology. Penetrating trauma to the region of the anterior chest bounded superiorly by the clavicles, inferiorly by the costal margin, and laterally by the nipple line—often referred to as “the box”—from projectiles or sharp-tipped objects can injure the heart or great vessels and precipitate tamponade.[5] In traumatic contexts, pericardiocentesis is typically viewed as a temporizing maneuver rather than definitive treatment. It is indicated in patients with blunt or penetrating trauma who are hemodynamically unstable, in cardiac arrest, or who demonstrate pericardial effusion on focused assessment with sonography for trauma (FAST) with hypotension that lacks another clear etiology.[6] Because time to definitive hemorrhage control is paramount, posttraumatic pericardiocentesis is commonly performed emergently at the bedside to stabilize the patient and facilitate rapid transfer to the operating room, where definitive interventions—such as

creation of a pericardial window, thoracotomy, or surgical pericardiectomy—can be performed. If pericardiocentesis fails to restore circulation or cannot be successfully completed, escalation to a bedside thoracotomy may be undertaken to allow direct pericardiectomy and drainage of tamponade, reflecting the high-stakes, algorithmic nature of resuscitation in traumatic arrest.[7] Across these indications, pericardiocentesis functions as both a therapeutic procedure—rapidly reversing the mechanical limitation imposed by an effusion—and a diagnostic intervention that can clarify etiology and guide subsequent management. The clinician's task is to recognize when an effusion is physiologically consequential or etiologically urgent, and to initiate drainage in a manner proportionate to the patient's stability and the anticipated need for definitive surgical treatment.

Contraindications

Pericardiocentesis is fundamentally a life-saving intervention when cardiac tamponade produces hemodynamic collapse; therefore, in an unstable patient with true tamponade physiology, there are no absolute contraindications. In this context, the clinical priority is rapid decompression of the pericardial space to restore ventricular filling and cardiac output. Even limited drainage may produce a disproportionately beneficial effect because a small reduction in intrapericardial volume can shift the patient back to a more compliant portion of the pericardial pressure-volume relationship, thereby improving blood pressure and end-organ perfusion.[8] Consequently, when deterioration is imminent, the risk-benefit balance strongly favors urgent drainage—ideally with imaging guidance when available, but not at the expense of delaying resuscitative intervention. Outside of immediate life-threatening tamponade, the procedural risks assume greater weight, and several relative contraindications should be considered carefully. A major concern is uncorrected coagulopathy and thrombocytopenia. Because pericardiocentesis traverses vascularized tissues and is performed adjacent to the heart and great vessels, impaired hemostasis increases the likelihood of clinically significant bleeding, including hemopericardium or procedural tamponade. When circumstances allow, clinicians should optimize coagulation parameters (e.g., correcting reversible coagulopathy and improving platelet count) before attempting elective or semi-urgent drainage, particularly if the effusion is stable and not causing shock [8].

Another important relative contraindication is an unclear diagnosis or inadequate procedural knowledge, especially regarding thoracic anatomy. Pericardiocentesis requires precise spatial awareness of the pericardial sac and adjacent structures such as the lungs, liver, coronary arteries, and internal mammary vessels. If the operator lacks adequate

anatomical familiarity or if bedside findings do not convincingly support pericardial effusion as the driver of instability, the risk of iatrogenic injury increases substantially. This becomes particularly critical when the effusion is suspected to be secondary to aortic dissection. In that scenario, pericardial blood may reflect a contained rupture; inadvertent puncture of the aorta or disruption of a tenuous seal can precipitate catastrophic hemorrhage. Thus, when aortic dissection is a realistic possibility and the patient is not in extremis, clinicians generally prioritize confirmatory imaging and surgical consultation over immediate percutaneous drainage. Patient cooperation is also relevant. Although emergent procedures may proceed under sedation or controlled airway management, compromised cooperation in a stable patient increases the risk of sudden movement, loss of sterile control, and needle misdirection. Lastly, active infection over the intended puncture site is a relative contraindication because it raises the risk of introducing pathogens into the pericardial space, potentially resulting in purulent pericarditis. When drainage is necessary but local infection is present, selecting an alternative access site and employing strict aseptic technique become essential to minimize iatrogenic infection [8].

Equipment

Successful and safe pericardiocentesis depends on having a complete set of imaging, monitoring, sterile procedural, and emergency-rescue resources immediately available. Contemporary best practice strongly favors real-time imaging guidance—most commonly transthoracic echocardiography—because it allows the operator to identify the largest fluid pocket, choose the safest entry trajectory, and continuously visualize needle advancement, thereby reducing complications such as myocardial laceration or coronary injury. Where echocardiography is unavailable or when procedural circumstances dictate, fluoroscopy can serve as an alternative guidance modality, particularly in catheter-based laboratories or when concurrent hemodynamic assessment is required. Regardless of the imaging platform, continuous electrocardiographic and hemodynamic monitoring is essential throughout the procedure to detect evolving arrhythmias, ischemic changes, or abrupt hemodynamic shifts that may signal complications or rapid physiologic improvement.[9] A standard sterile field must be established using sterile drapes, sterile gloves, antiseptic skin preparation, and appropriate personal protective equipment. Local anesthetic agents are required for infiltration of the skin and deeper tissues along the intended needle tract, both to improve patient comfort and to facilitate procedural cooperation in non-intubated individuals. Vascular-access style needles are typically employed; long, thin-walled needles in the 16- to 18-gauge range are commonly selected to allow controlled aspiration and to accommodate guidewire passage when using a Seldinger technique. Syringes—often 10 mL or 20

mL—are used during initial advancement to maintain continuous negative pressure while aspirating, enabling the operator to recognize entry into the pericardial space promptly [9].

For definitive drainage, a catheter system is required. A pigtail catheter, typically 6 to 8 French, is widely used because its curled tip reduces the risk of myocardial irritation and helps maintain stable intrapericardial positioning while permitting continuous drainage. A compatible guidewire is necessary for safe catheter placement and exchange, and sequential plastic dilators of varying diameters are used to enlarge the tissue tract gradually, minimizing trauma and facilitating smooth catheter insertion. Functional flow control requires a three-way stopcock and extension tubing to enable controlled aspiration, sampling, and connection to a closed drainage system. Additional accessories—including a scalpel to make a small skin nick for dilator passage, collection containers or drainage bags for measured output, sutures to secure the catheter, and an adhesive dressing to maintain site integrity—should be prepared before needle insertion. Finally, resuscitation and complication-management equipment should be immediately accessible, including oxygen delivery devices, suction, airway equipment, vasopressor support, and defibrillation capability, since pericardiocentesis is often performed in unstable patients and can precipitate arrhythmias or abrupt changes in preload and blood pressure.

Personnel

Pericardiocentesis is best executed as an interprofessional procedure in which each team member contributes specialized competencies that collectively reduce risk and improve outcomes. The primary operator is commonly a cardiologist, intensivist, emergency physician, or other clinician with procedural credentialing and detailed understanding of cardiac anatomy, pericardial pathophysiology, and ultrasound-guided needle techniques. Because image guidance is central to contemporary safety standards, the proceduralist may perform point-of-care echocardiography directly, or imaging support may be provided by a trained sonographer, echocardiographer, or radiologist who assists with acquisition and interpretation of real-time images, ensuring accurate localization of effusion and continuous visualization of the needle path. Nursing staff constitute a core component of the team. They prepare the patient, establish and maintain intravenous access, administer ordered medications, monitor vital signs continuously, and document procedural events, drainage volumes, and the patient's clinical response. Nurses also provide immediate recognition of deterioration—such as worsening hypotension, altered mental status, or respiratory compromise—and coordinate rapid escalation when needed. In many clinical environments, an anesthesiologist or sedation-qualified clinician is required to provide analgesia, anxiolysis, and airway management readiness,

particularly when the patient is agitated, unable to lie still, or at risk for respiratory decompensation during sedation. Respiratory therapists may support oxygenation and ventilatory management, especially in critically ill patients or those with concurrent pulmonary edema. Equally important is the availability of surgical backup. A cardiothoracic surgeon or trauma surgeon should be readily accessible when there is a high-risk etiology (for example, traumatic hemopericardium) or when percutaneous drainage may be incomplete, technically difficult, or likely to reaccumulate. This emergency surgical capability enables timely escalation to procedures such as a pericardial window, thoracotomy, or operative pericardiotomy if complications occur or if tamponade physiology persists despite attempted drainage. The integration of these roles within a coordinated workflow—supported by clear communication, closed-loop confirmation of critical steps, and shared situational awareness—directly supports procedural safety and effective management of pericardial effusions.[10]

Preparation

Preparation for pericardiocentesis is a structured sequence of clinical verification, risk mitigation, equipment readiness, and team coordination that begins before needle insertion and continues through immediate post-procedure monitoring. The process starts with focused patient evaluation to determine urgency and to identify tamponade physiology. Clinicians assess symptoms such as dyspnea and chest discomfort, examine tachycardia, hypotension, jugular venous distension, and muffled heart sounds when present, and evaluate perfusion status through mental state, urine output trends, and lactate when available. Because decompensation may be sudden, oxygen supplementation and respiratory support should be initiated early in patients with hypoxemia or distress, and hemodynamic stabilization—including intravenous access, fluid resuscitation when appropriate, and vasopressors when needed—should occur in parallel with procedural planning. Diagnostic imaging is the cornerstone of preparation. Bedside echocardiography confirms the presence, size, and distribution of pericardial fluid; identifies the optimal access window (subxiphoid, parasternal, or apical approaches depending on anatomy and effusion location); and evaluates hemodynamic consequences such as right atrial or right ventricular diastolic collapse and respiratory variation in transvalvular flows. In addition to echocardiography, fluoroscopic guidance may be used in select settings, particularly when catheter-based interventions are already underway [10].

Baseline laboratory testing supports risk assessment and peri-procedural decision-making. A complete blood count helps identify anemia or thrombocytopenia, coagulation studies inform bleeding risk and guide correction strategies when

time permits, and renal function testing assists with medication selection, contrast considerations, and overall physiologic assessment—particularly if procedural sedation is planned. Equipment preparation must be deliberate and systematic: imaging devices should be powered on and optimized, sterile kits opened without contaminating the field, and all drainage components assembled to avoid delays once the pericardial space is accessed. Continuous ECG and hemodynamic monitoring should be established before the procedure, and defibrillation capability should be verified. Patient positioning is tailored to maximize procedural success and safety. A semirecumbent or supine position with the head of the bed elevated approximately 30 to 45 degrees can improve effusion accessibility and patient comfort while maintaining oxygenation. Intravenous access must be confirmed, and analgesia and sedation administered judiciously to preserve protective reflexes and cooperation when feasible. The access site is selected based on imaging, then prepared with antiseptic solution and sterile draping. A time-out should confirm patient identity, indication, planned approach, allergy status, anticoagulation history, and availability of backup support [10].

Team readiness is finalized through explicit role assignment: one clinician advances the needle under imaging guidance, another monitors hemodynamics and administers medications, nursing staff document and assist with supplies, and surgical backup remains on standby for escalation. Preparation also includes an immediate postprocedure plan. If the intervention is diagnostic, fluid should be collected in appropriate sterile containers for laboratory analysis (including cytology and microbiology when indicated). After drainage, patients should remain in a high-acuity monitored setting so staff can rapidly detect complications such as reaccumulation, dysrhythmias, pneumothorax, bleeding, or persistent shock. This disciplined preparation framework improves procedural efficiency, reduces preventable errors, and strengthens patient safety across both emergent and elective pericardiocentesis contexts.

Technique or Treatment

Pericardiocentesis is a definitive, time-sensitive intervention for evacuating pericardial fluid when an effusion produces symptoms, diagnostic uncertainty, or hemodynamic compromise consistent with cardiac tamponade. From a therapeutic standpoint, the procedure aims to relieve elevated intrapericardial pressure, restore diastolic filling, and promptly improve cardiac output. From a diagnostic standpoint, it enables targeted sampling of pericardial fluid to identify infectious, malignant, inflammatory, traumatic, or metabolic etiologies. Contemporary practice strongly favors image-guided pericardiocentesis because real-time visualization improves success rates and reduces iatrogenic injury to the myocardium, coronary vasculature, lungs, liver,

and diaphragm. The overarching principle is that the safest technique is not defined by a single entry site, but rather by selecting the shortest and least hazardous trajectory to the largest accessible fluid pocket under imaging guidance, while maintaining continuous physiologic monitoring and readiness for immediate escalation if instability persists or complications occur.[11][12] Echocardiography-guided pericardiocentesis is widely regarded as the standard of care in most clinical environments, largely because it is portable, can be performed at the bedside, avoids ionizing radiation, and provides dynamic information about effusion distribution and tamponade physiology. The procedure begins with a focused echocardiographic assessment to confirm the presence of an effusion, estimate its size, define whether it is circumferential or loculated, and identify the region where the pericardial space is most safely accessible. The operator uses ultrasound not only to locate the optimal window but also to continuously confirm the needle's direction relative to the heart and adjacent organs. Prior to puncture, sterile preparation is performed, local anesthetic is infiltrated, and continuous ECG and hemodynamic monitoring are established to detect arrhythmias or abrupt blood pressure changes during needle advancement. In unstable patients, the procedure is commonly performed with minimal sedation to preserve spontaneous ventilation and protective airway reflexes, although analgesia and anxiolysis are provided as clinically appropriate [11][12].

Several anatomic approaches may be used during echocardiography-guided pericardiocentesis, and the selection is dictated by the effusion's location and the safest ultrasound-defined route. The subxiphoid (subcostal) approach is frequently used because it can provide access to anterior effusions while avoiding the pleural space in many patients. In this technique, the needle is introduced inferior to the xiphoid process and advanced toward the left shoulder under ultrasound guidance, with continuous aspiration applied. Although traditionally favored for its perceived safety profile, the subxiphoid route still carries risk if the effusion is small, posterior, loculated, or if abdominal structures are interposed; thus, modern practice emphasizes that ultrasound-defined anatomy should supersede routine habit. The apical approach is often selected when the largest fluid pocket is near the cardiac apex; entry typically occurs through the fifth or sixth intercostal space near the left midclavicular line, again guided by real-time echocardiography. This route can shorten the distance to the effusion but may increase pleural and pulmonary risk if the needle path traverses lung tissue, making careful imaging indispensable. The parasternal approach may be chosen when fluid is prominent anteriorly or laterally; puncture is commonly performed in the fourth or fifth intercostal space adjacent to the sternum, and ultrasound guidance helps minimize the risk of

internal mammary vessel injury. The suprasternal approach is less common but can be valuable in selected cases when the effusion accumulates superiorly or when other access routes are limited by anatomy or surgical constraints. Across all approaches, the procedural goal is to enter the pericardial space under imaging confirmation, aspirate fluid to relieve pressure, and then secure durable drainage when clinically indicated.[11][12]

Once the operator suspects entry into the pericardial space—typically suggested by free aspiration of pericardial fluid—catheter placement is performed using a guidewire-based technique to allow controlled conversion from a needle puncture to a stable drainage system. A sheathed needle or introducer system is advanced with steady aspiration. After aspirating fluid, the guidewire is inserted through the needle into the pericardial cavity under imaging visualization when feasible. The needle is then withdrawn, a small skin nick may be created, and sequential dilators are used to enlarge the tract. A pigtail catheter is advanced over the wire into the pericardial space, after which the wire is removed and the catheter is connected to a controlled drainage system using extension tubing and a three-way stopcock. Catheter position can be confirmed by echocardiography, and when uncertainty exists, agitated saline can be injected to produce echogenic microbubbles within the pericardial space, thereby verifying that the catheter tip is not intracardiac. This confirmation strategy is particularly useful in emergent circumstances when rapid decompression is required but visualization is challenging due to patient habitus, tachycardia, or suboptimal windows.[2] Fluoroscopy-guided pericardiocentesis remains an important technique in environments where echocardiography is unavailable, when the procedure is performed in a catheterization laboratory, or when concurrent invasive hemodynamic monitoring is needed. The patient is typically positioned supine, the access site—often subxiphoid—is prepared in sterile fashion, and local anesthesia is administered. Under fluoroscopic visualization, the needle is advanced toward the pericardium, with intermittent aspiration. Once fluid is aspirated, small-volume contrast injection may be used to confirm that the needle tip lies within the pericardial space rather than a cardiac chamber or vascular structure. A guidewire is then placed, and a pigtail catheter is advanced over the wire for drainage. Fluoroscopy can be advantageous for guiding wire and catheter manipulation, particularly in technically complex cases; however, it does not provide the same real-time soft tissue visualization as echocardiography, so careful technique and physiologic monitoring remain essential.

A recurring technical challenge in pericardiocentesis is differentiating true pericardial fluid from blood aspirated due to inadvertent entry into a cardiac chamber or epicardial vessel. Because no single method is universally definitive in all clinical

contexts, clinicians rely on a composite of immediate procedural cues and confirmatory strategies. Clotting behavior can provide rapid bedside information: intracardiac blood often clots, whereas pericardial effusion fluid—particularly inflammatory or serous effusions—typically does not. Hematocrit or hemoglobin assessment may help, as pericardial fluid usually has a lower hematocrit than chamber blood, although hemorrhagic effusions can confound this comparison. In situations of uncertainty, agitated saline injection with echocardiographic visualization of bubbles in the pericardial space offers strong confirmation of correct placement, and contrast injection under fluoroscopy may serve a similar role in catheterization settings. The fluorescein test has been historically described, but modern practice generally prioritizes echocardiographic and fluoroscopic confirmation because they directly visualize the catheter's anatomic compartment. If the needle inadvertently enters a cardiac chamber, the appropriate response is prompt withdrawal with immediate reassessment of hemodynamics and imaging. Many minor chamber punctures do not result in clinically meaningful hemopericardium, particularly when the puncture is small and the patient's coagulation status is acceptable; however, persistent bleeding, recurrent tamponade, or rapid hemodynamic deterioration mandates urgent surgical consultation and escalation. Because the consequences of ongoing bleeding can be catastrophic, the procedural team must maintain a low threshold for emergency notification of cardiac surgery when intracardiac puncture is suspected or when aspirated blood persists and the patient's stability does not improve as expected.[13]

Drain placement decisions are guided by the effusion's etiology, likelihood of reaccumulation, and the patient's clinical course. In acute tamponade, initial removal of a modest volume may yield dramatic physiologic improvement, but continued drainage may be necessary to prevent recurrence, especially in malignant, inflammatory, or post-procedural effusions. When a pericardial drain is placed, meticulous documentation of output is required, and staff should record drainage volumes and character at regular intervals, including every shift in inpatient settings, because trends in output can indicate ongoing bleeding, persistent inflammation, or catheter malfunction.[2] Catheter care also includes maintaining a closed system, minimizing introduction of air, ensuring secure fixation, and monitoring for local infection. Postprocedure management is integral to the overall treatment strategy and should be viewed as a continuation of the intervention rather than a separate phase. Immediately after drainage, patients require monitoring for arrhythmias, hypotension, vasovagal responses, re-expansion phenomena, bleeding, pneumothorax, or rapid reaccumulation of fluid. Repeat echocardiography is commonly used to confirm reduction of effusion size, assess cardiac filling, and verify catheter position if a drain remains

in place. When the procedure is performed for diagnostic purposes, pericardial fluid should be sent for targeted analysis based on clinical suspicion, recognizing that the ultimate resolution of the effusion depends on management of the underlying cause, such as infection, malignancy, autoimmune disease, or metabolic derangements. In cases where pericardiocentesis does not adequately relieve tamponade physiology, where the effusion is loculated and inaccessible, or where fluid reaccumulates despite catheter drainage, additional interventions—including a surgical pericardial window or operative drainage—may be required. The safest and most effective pericardiocentesis, therefore, is one embedded within a comprehensive plan that integrates imaging-guided technique, physiologic monitoring, disciplined catheter management, and definitive treatment of the causative pathology [2][12][13].

Complications

When performed by experienced clinicians in appropriately selected patients, pericardiocentesis is typically effective and associated with good clinical outcomes; nonetheless, it is not a benign procedure. Reported complication rates vary by patient acuity, effusion etiology, operator experience, and technique, but clinically meaningful adverse events occur in approximately 5% or more of cases, with many complications arising early and demanding immediate recognition and intervention.[14] This reality explains why contemporary standards emphasize imaging guidance—most commonly transthoracic echocardiography, and less commonly fluoroscopy or CT in selected settings—as a central risk-reduction strategy rather than a procedural luxury.[15][16] Even with ultrasound guidance, the operator is advancing a needle and catheter in close proximity to the myocardium and great vessels, so the procedural environment must be prepared for rapid deterioration. Accordingly, clinicians undertaking pericardiocentesis should have direct access to cardiothoracic surgical support, ideally within the same facility, because some complications require emergent surgical rescue, including thoracotomy, pericardial window creation, or repair of cardiac or vascular injury.[14] A major procedural hazard is myocardial injury, which can occur if the needle or guidewire enters a cardiac chamber or lacerates the epicardial surface. The clinical consequence may be hemorrhage into the pericardial space, producing iatrogenic tamponade—an especially dangerous scenario because it can evolve rapidly, sometimes after an initial transient improvement. If the perforation involves a low-pressure right-sided chamber, bleeding may be modest and self-limited; however, lacerations involving the left ventricle or atrial appendage, or injuries complicated by anticoagulation or thrombocytopenia, can precipitate massive hemopericardium and cardiovascular collapse. Chamber laceration can also lead to

persistent drainage of frank blood through the catheter, recurrent hemodynamic compromise, and echocardiographic evidence of reaccumulating effusion, all of which should trigger immediate escalation and surgical consultation.[14]

Needle malposition can also injure adjacent vascular structures. Coronary artery injury—particularly involving the right coronary artery or the left anterior descending artery—is a feared complication because it can cause hemopericardium, myocardial ischemia, arrhythmias, and sudden deterioration. Similarly, injury to the internal mammary artery or intercostal vessels, especially with parasternal approaches, can produce significant bleeding into the chest wall or pleural space. These vascular injuries underscore why procedural planning must integrate both surface landmarks and imaging-defined anatomy, and why clinicians must remain vigilant for early signs of hemorrhage, such as hypotension, tachycardia, expanding effusion, or unexpectedly high-volume sanguineous drainage.[14] Pulmonary complications are also clinically important. The pleural space and lungs are anatomically close to several access routes, particularly apical and parasternal approaches, making pneumothorax a recognized risk. Even a small pneumothorax can become clinically significant in patients with limited respiratory reserve or concurrent pulmonary edema. In addition to pneumothorax, pleural irritation, hemothorax, and diaphragmatic injury may occur if the needle traverses or traumatizes thoracic structures. Although imaging guidance reduces these risks, it does not fully eliminate them; therefore, postprocedure monitoring often includes attention to respiratory symptoms, oxygenation, and, when clinically indicated, confirmatory imaging such as a chest radiograph.[14] Abdominal and visceral injuries are classically associated with the subxiphoid approach, where the liver, stomach, or peritoneal contents may be at risk depending on anatomy and needle trajectory. Liver puncture or peritoneal violation may cause abdominal pain, bleeding, or hypotension, and may complicate subsequent management if the patient is anticoagulated or has coagulopathy. Such injuries highlight the importance of selecting the entry site based on the largest and safest effusion pocket rather than defaulting to a single “traditional” approach, particularly in patients with hepatomegaly, altered anatomy, or prior surgery.[14]

Electrophysiologic complications are common enough to merit explicit preparation. Mechanical irritation of the myocardium may provoke atrial or ventricular ectopy, and more serious dysrhythmias can occur if a needle or guidewire contacts the endocardium. Continuous electrocardiographic monitoring is therefore standard, and clinicians must be prepared to pause advancement, withdraw the needle, and treat arrhythmias according to severity. Alongside dysrhythmias, the procedure

can provoke a vagally mediated response. Acute decompression of the pericardial sac has been associated with vasovagal bradycardia and hypotension in a substantial minority of patients—reported in up to roughly one quarter—making it essential to anticipate transient hemodynamic shifts even when drainage is technically successful.[17] Prompt recognition, supportive care, and appropriate pharmacologic intervention, when indicated, are central to preventing secondary injury. A distinct and potentially dramatic complication is acute cardiac decompression syndrome. This entity is characterized by paradoxical hemodynamic deterioration and pulmonary edema following drainage, and it appears most commonly when large volumes of pericardial fluid are removed rapidly.[18] The proposed mechanisms include abrupt changes in ventricular loading conditions, alterations in ventricular interdependence, and transient myocardial dysfunction. Clinically, the syndrome is important because it can occur after the operator and team have interpreted the procedure as “successful.” Consequently, many clinicians adopt a strategy of controlled, staged drainage—especially in chronic, large effusions—and maintain close postprocedure surveillance to detect early respiratory distress, hypoxemia, or recurrent hypotension.[18]

Finally, infectious complications, though less frequent than mechanical or hemodynamic events, remain relevant because pericardiocentesis breaches sterile tissue planes and often leaves an indwelling catheter. Infection risk increases with prolonged catheter dwell time, breaks in sterile technique, or contamination of the drainage system. Local site infection, mediastinal infection, and iatrogenic pericarditis are possible, reinforcing the necessity of strict asepsis, careful catheter care, and daily reassessment of whether ongoing drainage is still required.[2] In rare but catastrophic circumstances, pericardiocentesis-related complications culminate in death, typically through uncontrolled hemorrhage, refractory tamponade, malignant arrhythmias, or delayed recognition of postprocedure decompensation.[14] In aggregate, the recognized complications include chamber laceration, injury to the internal mammary or intercostal vessels, coronary artery injury, pneumothorax, arrhythmias, hypotension and vasovagal responses, liver or peritoneal puncture, infection, and death.[14] The consistent theme across these adverse events is that risk is mitigated—though not abolished—by image guidance, meticulous technique, continuous monitoring, and immediate access to definitive surgical intervention when required.[15][16]

Clinical Significance

Pericardiocentesis occupies a central place in acute cardiovascular care because it can be immediately life-saving in patients with cardiac tamponade, a condition in which rising intrapericardial pressure compromises diastolic filling, reduces stroke

volume, and culminates in shock or arrest if untreated.[19] In this setting, the clinical value of the procedure is defined not only by its technical ability to remove pericardial fluid but also by its capacity to rapidly restore circulatory physiology. Even the withdrawal of a relatively small volume of fluid may shift the patient back to the compliant portion of the pericardial pressure-volume relationship, resulting in prompt improvement in blood pressure, relief of tachycardia, reduced venous congestion, and resolution of pulsus paradoxus. The time-sensitive nature of tamponade is therefore a primary reason pericardiocentesis is considered a “do-or-die” skill in many emergency and cardiology environments; failure to identify tamponade physiology and intervene without delay can lead to preventable mortality.[19] Beyond emergent tamponade, pericardiocentesis has substantial diagnostic and therapeutic relevance for symptomatic pericardial effusions that cause dyspnea, chest discomfort, or functional decline, and for effusions of uncertain etiology requiring fluid analysis. Pericardial fluid sampling can contribute to etiologic clarification in conditions such as malignancy-associated effusion, inflammatory or autoimmune pericardial disease, and infectious pericarditis, where cytology, culture, and biochemical testing may influence targeted therapy and prognosis. From a therapeutic perspective, drainage can alleviate symptoms and prevent progression to hemodynamic compromise in patients with large effusions, particularly when the clinical trajectory suggests ongoing accumulation. Importantly, pericardiocentesis is also frequently deployed in the management of iatrogenic pericardial bleeding, including hemopericardium following coronary or structural heart interventions, electrophysiology procedures, catheterization, or device-related perforation such as pacemaker or defibrillator lead injury.[19] In these cases, pericardiocentesis may serve as definitive treatment or as a stabilizing bridge while surgical or percutaneous repair is organized.

Modern practice has reinforced the expectation that pericardiocentesis should be image-guided whenever feasible, typically using echocardiography at the bedside or fluoroscopy in catheterization laboratories, because real-time visualization improves the likelihood of successful drainage and reduces procedural complications.[3] The expansion of complex electrophysiology ablations, transcatheter valve therapies, left atrial appendage occlusion, and other structural interventions has increased the clinical scenarios in which rapid pericardial access must be achieved under pressure. As a result, mastery of image-guided technique, familiarity with multiple access routes, and competence in catheter-based drainage strategies are increasingly essential for contemporary cardiologists and other clinicians who work in acute cardiac care environments. Proficiency also includes anticipating postdrainage physiology, recognizing decompression-

related deterioration, and determining when pericardiocentesis is insufficient and urgent surgical drainage is required. In sum, pericardiocentesis is clinically significant because it converts a potentially fatal hemodynamic catastrophe into a treatable state, while also functioning as a high-yield diagnostic and symptom-relieving intervention across a wide spectrum of pericardial disease.[19]

Enhancing Healthcare Team Outcomes

Optimal pericardiocentesis outcomes depend on coordinated, interprofessional performance rather than operator skill alone. The procedure is often performed in unstable patients, under time constraints, and within anatomically high-risk territory; therefore, team readiness, shared situational awareness, and disciplined communication are major determinants of safety. The clinician performing the procedure—commonly a cardiologist or similarly trained specialist—leads diagnostic synthesis, selects the safest access route based on imaging and anatomy, and executes needle entry, guidewire placement, catheter insertion, and controlled drainage. However, procedural success is tightly coupled to the surrounding team's ability to prepare the patient, ensure correct equipment and monitoring, anticipate decompensation, and respond immediately to complications such as arrhythmia, hypotension, or recurrent tamponade physiology. Nursing contributions are foundational throughout the workflow. Before needle insertion, nurses support rapid stabilization, confirm continuous electrocardiographic and hemodynamic monitoring, establish and secure intravenous access, prepare the skin with strict aseptic technique, and maintain the sterile field—actions that reduce infection risk and prevent avoidable delays. During the procedure, nurses provide high-frequency surveillance of vital signs, patient symptoms, and drainage characteristics, while also serving as a communication bridge between the operator, anesthesia or sedation personnel, and imaging support. After catheter placement, nursing teams are essential for structured postprocedure monitoring to detect early warning signs of deterioration, including falling blood pressure, escalating tachycardia, worsening dyspnea, reduced oxygen saturation, or increasing drain output that may suggest ongoing bleeding. Clear documentation of drain output and trends is not clerical detail; it is clinical surveillance that can trigger timely escalation to echocardiography, transfusion, or surgical consultation when required.

Pharmacists strengthen safety by ensuring immediate availability and appropriate dosing of sedatives, analgesics, vasoactive agents, and emergency medications needed to manage procedure-related hemodynamic instability. Their role is particularly important when patients have complex comorbidities, renal impairment, or polypharmacy that affects sedation risk, anticoagulation reversal, or drug

interactions. Anesthesiologists or sedation specialists contribute by titrating sedation to balance patient comfort with the need to preserve respiratory function and hemodynamic stability—an especially delicate task in tamponade, where preload dependence and limited cardiac reserve can make patients vulnerable to hypotension. Imaging specialists, including sonographers or radiologists when involved, enhance precision by assisting with real-time identification of the largest and safest effusion pocket, confirming needle trajectory, and verifying catheter position, thereby reducing the likelihood of lung, liver, or myocardial injury.[3]

Team outcomes improve further when institutions adopt standardized protocols for pericardiocentesis, including preprocedure checklists, role assignment, and closed-loop communication practices that confirm critical steps such as anticoagulation status, equipment readiness, surgical backup availability, and postprocedure monitoring plans. Structured handoffs—from the procedural location to intensive care or step-down units—reduce the risk of missed complications by ensuring that receiving teams understand the effusion etiology, volume removed, catheter status, drainage thresholds that require escalation, and the plan for follow-up echocardiography. Regular interdisciplinary rounds after the procedure allow rapid alignment on evolving clinical data and timely adjustment of the care plan, such as decisions about continued drainage, catheter removal, diagnostic testing of fluid, escalation to pericardial window, or targeted treatment of the underlying disease process. In this way, pericardiocentesis becomes not merely a technical intervention but a coordinated episode of care in which interprofessional collaboration directly translates into safer procedures, fewer complications, and higher patient confidence and satisfaction.[19]

Conclusion:

Pericardiocentesis is a cornerstone intervention in managing pericardial effusions, particularly when tamponade physiology threatens circulatory stability. Its clinical significance lies in its ability to rapidly reverse obstructive shock and restore cardiac filling, often transforming a fatal scenario into a treatable condition. Beyond emergent contexts, the procedure offers diagnostic clarity and symptomatic relief in diverse etiologies, including malignancy, infection, and postoperative syndromes. However, its execution demands precision: the pericardial space is anatomically constrained and surrounded by vital structures, making blind techniques increasingly obsolete. Contemporary standards advocate real-time imaging—preferably echocardiography—to guide needle trajectory, confirm catheter placement, and minimize iatrogenic harm. Despite these advances, complications such as myocardial injury, vascular trauma, pneumothorax, and infection remain possible, underscoring the need for vigilant monitoring and

immediate surgical backup. Optimal outcomes hinge on interprofessional coordination, structured preparation, and adherence to safety protocols, including controlled drainage strategies to prevent decompression-related deterioration. Ultimately, pericardiocentesis exemplifies the intersection of technical skill, physiologic insight, and team-based care, reaffirming its indispensable role in modern cardiovascular practice.

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