Technical Note

An Improved Device Clears Blockages in the Tube of Irrigation and Drainage Systems

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Abstract: The outflow tube may be blocked during continuous irrigation for the treatment of septic joints. Although multiple solutions have been applied to clear the blockage, there are still many disadvantages. The success rate is difficult to guarantee, and bacteria may enter the joint cavity and cause secondary infection. We designed an improved irrigation and drainage system that avoids these disadvantages and is particularly convenient to use. In addition, the improved system provides more thorough lavage and drainage and prevents joint adhesion.

Intra-articular infection, especially after graft placement, is a relatively rare but serious complication.[1] Various treatment options have been proposed, with surgeons generally agreeing on emergency surgery, irrigation and debridement of the joint, and administration of intravenous antibiotics.[2,3] Some problems are occasionally encountered during continuous irrigation. One of the most common is tube blockage, especially in the outflow tube. The common solution is to use a syringe to aspirate or inject saline solution through the lower tube to break off the blockage or reverse the direction of flow, making the superior tube the outflow and the lower tube the inflow.[4,5] However, the interface between the syringe and the lower tube may not match perfectly, resulting in a lack of adequate pressure to clear the blockage. Because the tube may be blocked more than once, repeated separation and connection of the lower tube for aspiration or injection of saline solution may cause bacteria to adhere to the tube wall and then enter the joint cavity during the process of injection. As the irrigation time increases, bacteria will also breed in the drainage bag and spread to the lower tube. Treating the lower tube contaminated with bacteria as the inflow tube may cause bacteria to enter the joint cavity during subsequent irrigation.

We designed an improved irrigation and drainage system that can easily clear blockages in tubes. All operations are sterile and simple.

Materials

The materials needed are as follows: sodium chloride irrigation solution in a 3-L bag (0.9%; Chengdu Qingshan Likang Pharmaceutical), infusion set (no intravenous needle required; Shandong Weigao Group Medical Polymer), 3-way stopcock (Becton, Dickinson and Company), sputum-aspirating tube (4.0 mm × 360 mm, F12; Yangzhou Guilong Medical Device), urine drainage bag (Guangzhou Huashan Medical Plastic Factory), and sterile syringe (20 mL; Shandong Weigao Group Medical Polymer).

Construction Steps

The improved irrigation and drainage system is installed (Fig 1, Video 1). The rubber mouth of the sodium chloride irrigation solution is punctured with the A end of the infusion set to connect the two (Fig 2A). The C end of the 3-way stopcock is connected with the B end of the infusion set, the D end of the 3-way stopcock is protected with a cover to prevent bacterial contamination, and the E end of the 3-way stopcock is connected with the F end of the sputum-aspirating tube (Fig 2B). Several side holes are cut at intervals of 0.5 cm near the G and g ends of both sputum-aspirating tubes (the exact number depends on the size of the joint cavity), one for the inflow tube and

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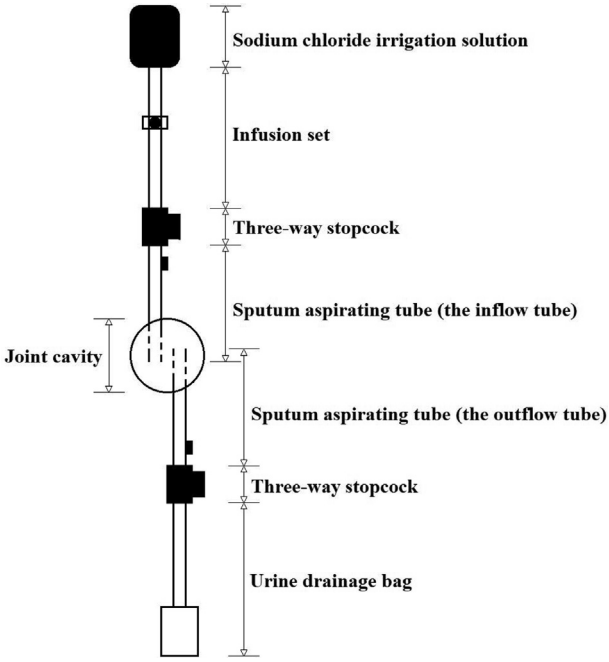

Fig 1. Improved irrigation and drainage system.

one for the outflow tube (Fig 2C). It is important to ensure that all side holes are in the joint cavity when both sputum-aspirating tubes are fixed to the skin. The piston of the T-shaped tube of both sputum-aspirating tubes is closed to form a closed cavity (Fig 2C). The e end of another 3-way stopcock is connected with the f end of the outflow tube, the d end of this 3-way stopcock is protected with a cover to prevent bacterial contamination, and the c end of this 3-way stopcock is connected with the h end of the urine drainage bag (Fig 2D).

During continuous irrigation, the valve in the 3-way stopcock is connected to the outflow tube at approximately 0° (Fig 3A). If the joint cavity is not filled enough, the angle of this valve can deviate from 0°, or the rate of inflow can be increased through the infusion set's flow regulator to keep the joint cavity inflated (Fig 3 A and B). If the joint cavity is overfilled, the opposite can be performed. The valve in the 3-way stopcock connected with the inflow tube is always maintained at 0° (Fig 3C). When the tube is blocked, the most likely reason is fibrin debris from the joint in the outflow tube. In this case, the valve in the 3-way stopcock connected with the outflow tube is rotated 90° and a syringe is used to aspirate or inject saline solution by the d end of the 3-way stopcock (Fig 3D). Aspiration should be performed first, and if this does not work, then fluid can be injected. Intermittent aspiration and injection may be more effective than continuous aspiration and injection. Table 1 lists the situations one might encounter and the solutions when injecting saline solution.

If much resistance is felt while injecting or aspirating saline solution, the reason for the blockage has been found in the outflow tube. At this point, some force may be required to inject saline solution with the syringe and prevent the syringe or 3-way stopcock from falling off because the pressure in the tube is very high. The capacity of the syringe should be 20 mL. A syringe with too small a volume cannot provide sufficient pressure for aspiration or injection. If the outflow tube is still completely blocked after injection of 20 mL of saline solution, the inflow tube should also be checked for a blockage instead of injecting saline solution indefinitely. When the outflow tube is blocked, causing the fluid in the joint cavity to stop flowing, the inflow tube is also prone to blockage. At this point, the blockage in the inflow tube can be cleared in the same way as a blockage in the outflow tube. If no resistance is felt while injecting saline solution, then one should consider other causes, such as folding and twisting of the tube, the wrong irrigation speed, or improper suspension height of the sodium chloride irrigation solution and drainage bag. However, the likelihood of a blockage in the inflow tube is very small. When the outflow tube is not blocked, the continuous inflow of sodium chloride irrigation solution prevents fibrin debris from blocking the inflow tube. The cause of the blockage can be easily and clearly determined by the 3-way stopcock connected to the inflow and outflow tubes.

Discussion

Continuous irrigation has been applied in the treatment of septic arthritis and obtained significantly improved results.[6,7] Continuous irrigation has the following theoretical advantages: diluting the enzymatically active material with possible cartilage protection, diluting the concentration of the causative organism, increasing the efficiency of systemic antibiotics, and removing the necrotic material persistently.[5] If the blockage in the tube is not cleared, irrigation has to be stopped early.

Compared with the traditional irrigation and drainage system, this improved system has the following advantages and disadvantages (Table 2): The most important contribution of the improved system is that all processing operations are sterile. In addition, this system forms a pressure difference between the proximal and distal ends of the joint cavity, inflating the joint capsule continuously. This can provide more thorough irrigation and drainage and prevent joint adhesion. The remaining blood clots, necrotic tissue, and synovial tissue in the joint cavity may block the

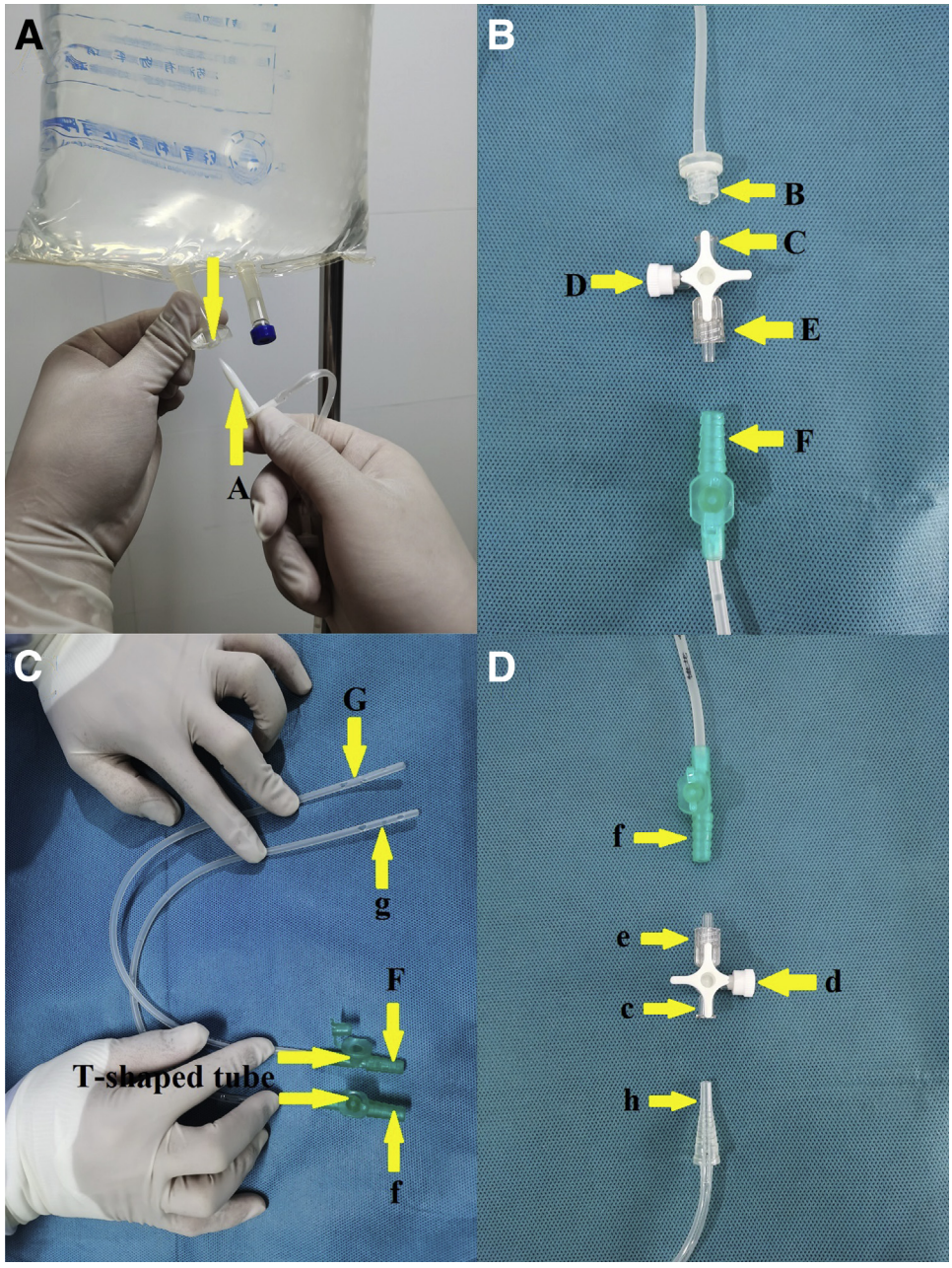

Fig 2. Structure of improved irrigation and drainage system. (A) The rubber mouth of the sodium chloride irrigation solution is punctured with the A end of the infusion set. A is the tip of the infusion set. (B) The 3-way stopcock connected with the inflow tube is connected with other materials. B and C are the ends of the connection between the infusion set and the 3-way stopcock. D is used to connect the sterile syringe when the inflow tube is checked for a blockage. E and F are the ends of the connection between the 3-way stopcock and the sputum-aspirating tube. (C) One sputum-aspirating tube is the outflow tube; the other is the outflow tube. G and g are the ends of the side holes of the two sputum aspirating tubes. F and f are the end of the two sputum-aspirating tubes connected with the 3-way stopcocks. (D) The 3-way stopcock connected with the outflow tube is connected with other materials. f and e are the ends of the connection between the 3-way stopcock and the sputum aspirating tube. d is used to connect the sterile syringe when the outflow tube is blocked. c and h are the ends of the connection between the 3-way stopcock and the urine drainage bag.

inlet of the drainage tube in the early postoperative period. In addition, irrigation and drainage systems may not work for several reasons. Joint mobilization might cause tubes to fold and twist, resulting in blockage. This problem is usually solved by adjusting the limb to the correct position. Improper irrigation speed and suspension height of the sodium chloride irrigation solution and drainage bag may also occur. The drainage bag should be at least 30 cm below the affected limb, and sodium chloride should be injected 140 cm above the bed surface. The amount of sodium chloride injected (0.9%) for irrigation is 3 L/d on average (range, 2,500-4,000 mL; 60-80 drops/min), and a higher inflow rate (500 mL/h) is used to prevent early blockage.[8]

To date, we have not found any obvious disadvantages to clearing blockages during continuous irrigation by the improved lavage and drainage system. This method can be used to treat other septic joints (e.g., knee and shoulder) and applied to areas requiring irrigation and drainage for conditions such as osteomyelitis. Considering that our device is simple and costs little, it may be developed into a standard, reliable, inexpensive, and disposable product in the future (Table 2).

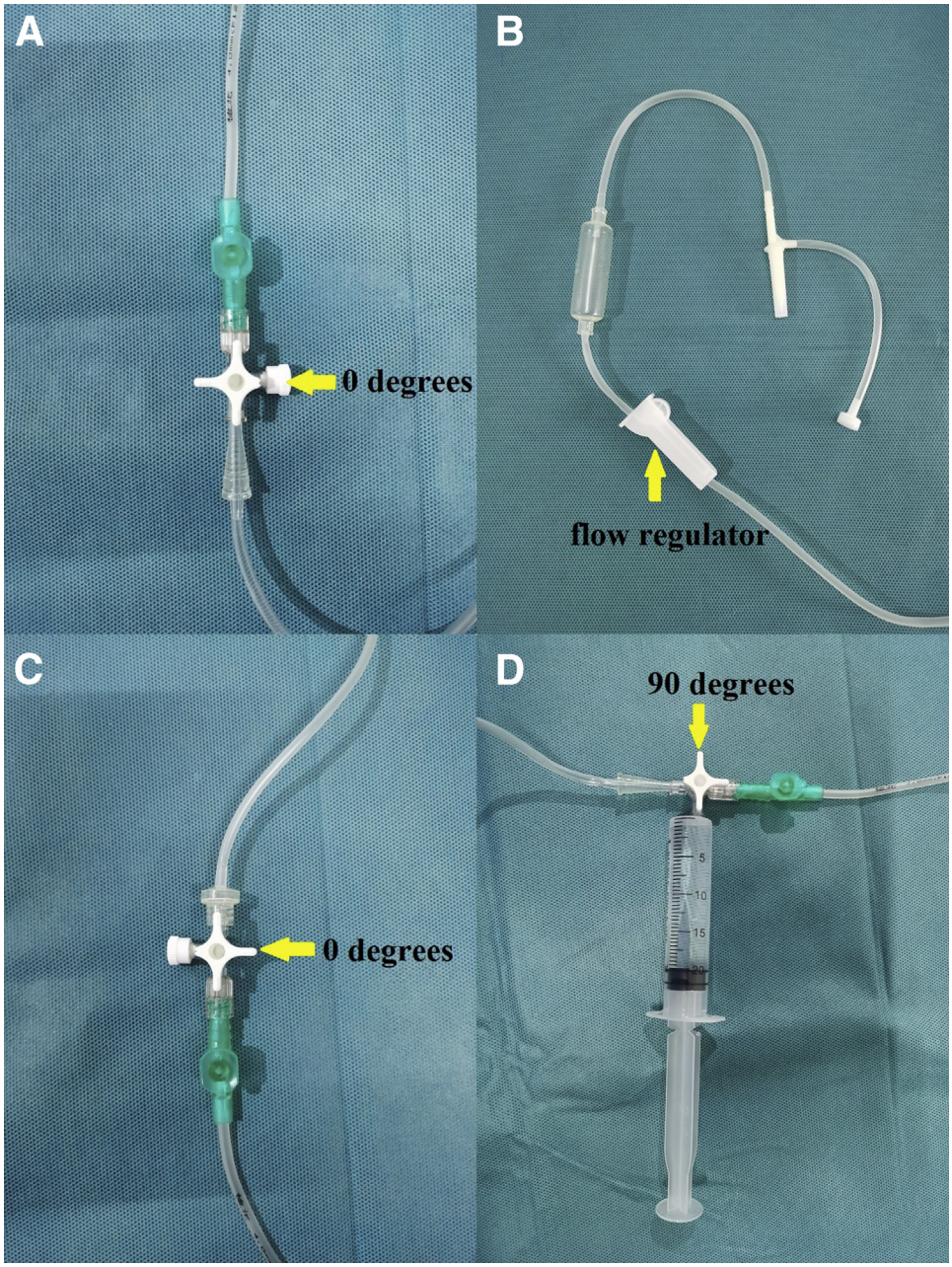

Fig 3. Position of valve in 3-way stopcock and connection of syringe. (A) The valve in the 3-way stopcock is connected to the outflow tube at approximately 0°. (B) The rate of inflow can be increased through the infusion set's flow regulator to keep the joint cavity inflated. (C) The valve in the 3-way stopcock connected with the inflow tube is always maintained at 0°. (D) A syringe is used to aspirate or inject saline solution.

Table 1. Situations One Might Encounter and Solutions When Injecting Saline Solution

Situation	Solution
Resistance is felt and saline solution cannot be injected.	One should check the position of the valve in the 3-way stopcock or apply more force for injection.
Resistance is felt and the system is working again after injection.	The outflow tube is blocked, and the blockage has been cleared.
Resistance is felt and the system still does not work after injection.	The inflow tube should be checked for a blockage instead of injecting saline solution indefinitely.
Resistance is not felt and irrigation has been interrupted before.	The inflow tube should be checked for a blockage.
Resistance is not felt and irrigation has never stopped.	One should consider other causes, such as twisting of the tube, the wrong irrigation speed, or improper suspension height.

Table 2. Advantages and Disadvantages of Improved Irrigation and Drainage System

Advantages
All processing operations are sterile and simple.
The system keeps the joint cavity inflated, providing more thorough lavage and drainage and preventing joint adhesion.
The cause of blockages can be easily and clearly determined.
The interface between the syringe and the lower tube matches perfectly, providing adequate pressure to clear blockages.
The improved system is very simple. Any surgeon can assemble it easily.
The materials are very inexpensive and standard.
The materials for the system can be obtained in any operating room.
Disadvantages
Because the interface between the syringe and the lower tube matches perfectly, the pressure in the tube is very high. Some force may be required to prevent the syringe or 3-way stopcock from falling off.

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