

Development of a comb needle with five needles for securing access to large blood vessels during emergency resuscitation

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Abstract

Purpose Animal tests have indicated that providing venous–arterial (V–A) bypass extracorporeal circulation immediately after cardiac arrest is a useful resuscitation technique for achieving resumption of a normal cardiac function and brain resuscitation. However, pulsation of the femoral artery cannot be felt in the case of cardiac arrest, and it takes a long time to puncture the femoral artery and vein. We developed a comb needle that has five 18-gauge metallic needles fixed in parallel on a plastic board. In this study, we investigated whether the comb needle would achieve puncturing of the femoral artery and vein in cadavers.

Methods The comb needle was used to puncture the femoral artery and the femoral vein in 45 donated bodies. We placed the center needle of the comb needle 2 cm perpendicularly caudal to a point approximately one quarter the distance along a straight line connecting the anterior superior iliac spine and the pubic tubercle. An autopsy was performed following puncturing, and it was determined whether needles of the comb needle punctured the femoral artery and/or the femoral vein.

Results Puncturing of both the femoral artery and the femoral vein was achieved in 35 cases (78%). In the left groin, both the femoral artery and the femoral vein were punctured in 16 cases (94%), and in the right groin, both the femoral artery and the femoral vein were punctured in 19 cases (68%).

Conclusion Using a comb needle, one insertion can achieve simultaneous puncturing of the femoral artery and the femoral vein with a high success rate in cadavers.

Keywords Comb needle · Femoral vessel catheterization · Cardiac arrest · Cardiopulmonary bypass · Cardiopulmonary resuscitation

Introduction

Animal studies have indicated that if venous–arterial (V–A) bypass extracorporeal circulation is established in the patient immediately after the occurrence of cardiac arrest, resumption of a normal cardiac function may occur and resuscitation of brain function may be improved [1, 2]. In addition, it has been found that a rapid decrease in body temperature to 34°C after the occurrence of cardiac arrest using a venous–venous (V–V) bypass circulation during the resuscitation from cardiac and respiratory arrest reduces the level of brain damage [3]. One of the important problems associated with the application of V–A or V–V bypass circulation to patients suffering cardiac arrest is the difficulty in establishing the arterial and venous access routes. The femoral pulse cannot be felt in the case of cardiac arrest, and it takes time to puncture the femoral artery and vein. A comb needle with five, 18-gauge metallic needles was experimentally designed to achieve useful punctures into the femoral artery and femoral vein

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with a blind puncture into the skin of the groin area in the event of cardiac arrest. In this study, we examined whether the comb needle could achieve puncturing of the femoral artery and femoral vein in a cadaver.

Materials and methods

All procedures were performed in accordance with the ethical guidelines of Kumamoto University, Kumamoto, Japan. The informed consents for donation of bodies included the purpose of medical research as well as education. The study used 45 donated bodies that had been provided to the educational anatomical course at Kumamoto University Graduate School of Medicine.

A comb needle is a device with five 18-gauge metallic needles, and the length of each needle is 40 mm (Fig. 1). In the comb needle, the five metallic needles are fixed in parallel at 5 mm intervals on a plastic board. The comb needles were produced by Medikit and provided free of charge for use in this experiment.

Our preliminary study in adult patients under general anesthesia demonstrated that the strongest pulsation of the femoral artery was located 2 cm perpendicularly caudal to a point a quarter of the distance along a straight line connecting the anterior superior iliac spine and the pubic tubercle. As previously described, the femoral artery pulse is palpable at approximately the same place between the

anterior iliac spine and the pubic tubercle in an adult human [4]. Our preliminary study also indicated that height, body weight, and gender were not related to the strongest pulsation of the femoral artery, and we did not record the heights, body weights, or genders of the donated bodies. We determined points A, B, C, and D according to the results of a preliminary experiment (Fig. 2). Points of the anterior superior iliac spine (point A) and pubic tubercle (point B) were marked on cadavers. The length between A and B was measured with a ruler, and the point a quarter of the length, from point B, was established as point D. The position 2 cm caudal from point D perpendicular to AB was established as point C. The center needle of the five needles of the comb needle was placed at point C. Puncture direction was parallel to body axis at a puncture angle of approximately 45° to the skin, and the insertion depth was approximately 2–3 cm. An autopsy was performed following puncturing to record which needles of the comb needle punctured the femoral artery or vein. In this study, we did not investigate whether the needles had penetrated the vessels, because we used donated bodies provided to the educational anatomical course and it is very difficult to find the locations of the tips of needles without causing anatomical damage.

Fisher's exact test was used to compare the successful puncture rate in the left compared with the right groin. Critical values that reached a $p < 0.05$ level of significance were considered statistically significant.

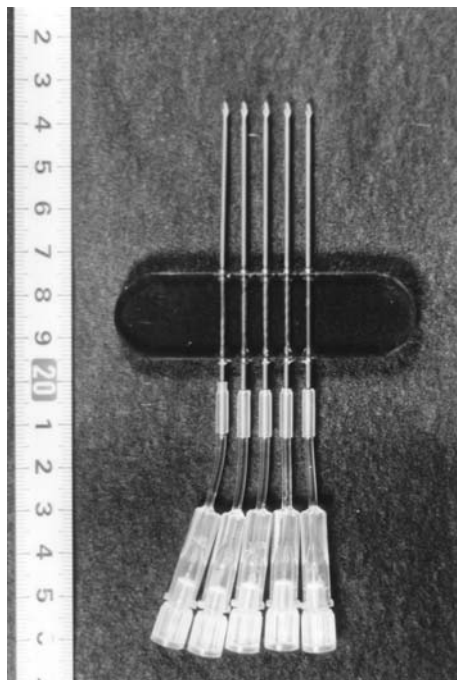


Fig. 1 A comb needle with five, 18-gauge metallic needles fixed in parallel on a plastic board. Needle length: 40 mm, needle spacing 5 mm

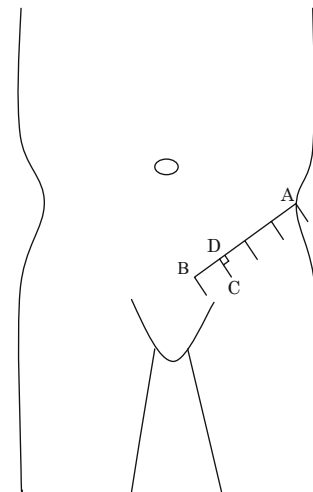


Fig. 2 Points for puncturing femoral artery and femoral vein in the systemic anatomy. Points in the systemic system on both sides of the anterior superior iliac spine (point A) and pubic tubercle (point B) were marked on 45 bodies. The length between A and B was measured with a ruler, and the point at one fourth the distance from the inside (closer to point B) was established as point D. The position 2 cm caudal from point D perpendicular to AB was established as point C

Results

Using the comb needle, a successful puncture of both the femoral artery and femoral vein with one attempt was obtained in 35 out of 45 cases (78%). The successful puncture rate in the left groin region was 94% (16 out of 17 cases) and that in the right groin region 68% (19 out of 28 cases). There is no statistically significant difference in the successful puncture rate between left and right groin ($p = 0.064$). An unsuccessful puncture of both the femoral artery and femoral vein occurred in one of 17 cases in the left-side study and in two out of 28 cases in the right-side study. In these cases, the cadavers were fatty and needle penetration to a depth of 3 cm was too little to reach the femoral artery and femoral vein. In the right-side study, punctures of only the femoral artery occurred in five out of 28 cases, and punctures of only the femoral vein occurred in two out of 28 cases. In the left-side study, puncture of only the femoral artery or puncture of only the femoral vein did not occur.

When more than three needles reached the femoral vessels (left side: 16 out of 17 cases; right side: 18 out of 28 cases), the innermost needle of the comb needle that reached the femoral vessels reached the femoral vein, and the outer-most needle that reached the femoral vessels reached the femoral artery. When less than two needles reached the femoral vessels (left side: 0 out of 17 cases; right side: 8 out of 28 cases), successful puncture of both the femoral artery and femoral vein occurred only in one out of eight cases. When the right groin region was punctured, all five needles of a comb needle have a chance to puncture the femoral artery, and the inner four needles of the comb needle have a chance to puncture the femoral vein (Fig. 3). On the other hand, when the left groin region was punctured, the outer four needles have a chance to puncture the femoral artery and the inner three needles have a chance to puncture the femoral vein (Fig. 3).

Discussion

In this study, 45 donated bodies were punctured with comb needles, and the success rate of puncture of both the femoral artery and femoral vein was 78%. Especially in the left groin region, the successful puncture rate was 94%. The success rate for the puncture of the femoral vein during active resuscitation has been reported to be around 65% when the landmark-oriented technique was used [5]. The method we used can be considered to be superior because the puncture point is not determined based on pulsation at the groin, and a puncture can be made at the correct point during cardiopulmonary resuscitation. Moreover, puncture point is not related to height, body weight, or gender. This

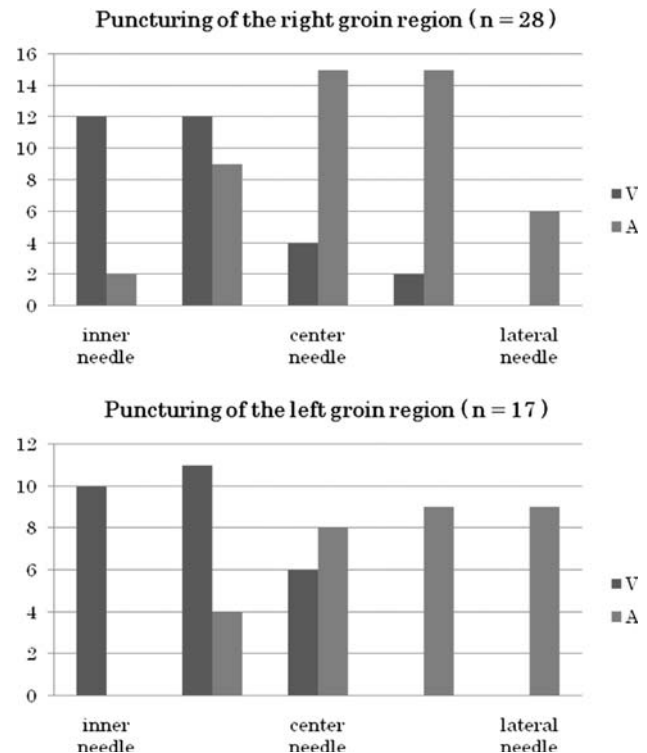


Fig. 3 Results of an autopsy performed following puncture of the femoral artery and femoral vein in the systemic anatomy of 45 cadavers using the comb needle. V puncturing of the femoral vein, A puncturing of the femoral artery Y-axis number of punctures into vessels with the comb needle

also indicates the superiority of the method during a clinical emergency.

Although there was no statistically significant difference between puncture success rate of both the femoral artery and femoral vein in the left groin and that in the right groin, the success rate of punctures of both the femoral artery and femoral vein on the left side (94%) was higher than that on the right side (68%). In the right groin study, all five needles have a chance to hit the femoral artery, and the inner four needles have a chance to hit the femoral vein. In the left groin study, the outer four needles have a chance to hit the femoral artery, and the inner three needles have a chance to hit the femoral vein. These data suggest that variation of the interval between the femoral artery and femoral vein in the right groin region is larger than that in the left groin region. We think this is why the successful puncture rate in the left side was higher than that in the right side.

It is important to distinguish between an artery and a vein when V–A bypass extracorporeal circulation is started; however, it is difficult to distinguish between an artery and a vein when observing only blood color during cardiopulmonary resuscitation. When a comb needle is used, it is easy to distinguish between the femoral artery and the

femoral vein. When more than three needles punctured vessels, the outermost needle punctured the femoral artery and the innermost needle punctured the femoral vein.

Hilty et al. [5] reported that it took 33 s to find the flash of blood by the finder needle and took 124 s to establish functional catheter placement to the femoral vein with the standard landmark-oriented approach in patients requiring intravenous access during cardiopulmonary resuscitation. We did not use a comb needle clinically and we do not know how long it will take to establish a venous access route in such patients. From our data, a flash of blood from the femoral artery and/or vein with one puncture of a comb needle can be found with a high success rate, and it is believed that a comb needle may be useful for catheterization into the femoral artery and vein during cardiopulmonary resuscitation. We only examined whether the needles punctured the femoral artery or the femoral vein and did not examine the location of the needle tips. In this experiment, we did not pass a guide wire in the comb needle. It is obvious that the type of needle having a guide wire is safer and more useful in cannulation to establish an extracorporeal circuit. In the next study, we need to clarify whether a guide wire can pass through the needles of a comb needle safely and whether a catheter can be inserted through the guide wire in an animal study. We also need to examine whether the use of a comb needle may shorten the time to establish percutaneous cardiopulmonary support PCPS in patients with cardiac arrest.

In this experiment, there were three cases in which the needles did not reach the vessels when the needles were inserted 3 cm into the cadavers. In these cases, the puncture point was appropriate but the cadavers were fatty. Thus, we need to examine the appropriate depth of needle insertion and appropriate needle length. The appropriate

spacing between the needles has not been fully examined either. These points require further investigation.

It has been reported that application of emergent PCPS to patients in cardiac arrest improved survival rates [6]. Rapid establishment of blood access routes is a huge barrier to rapid application of the PCPS system. A comb needle may shorten the time to establish blood access routes and may be useful during cardiopulmonary resuscitation. In conclusion, using a comb needle, one puncture can achieve simultaneous puncturing of the femoral artery and femoral vein at a high success rate in cadavers.

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