Small Volume Resuscitation in Hemorrhagic Shock: Historical and Scientific Background

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ABSTRACT

Exsanguination is the primary cause of death in trauma. The mortality can be prevented if bleeding can be stopped and blood loss can be replaced with fluid. Fluid resuscitation has been proven to improve tissue perfusion and reverse the cellular injury and swelling in state of hemorrhage. Fluid resuscitation can also depress the cytokines that could lead to multiple organ failure in hemorrhagic shock. The method of fluid resuscitation widely used nowadays refers to guideline by American College of Surgeon. Despite its wide application, some studies reported the guideline may be harmful and addressed the lack of its scientific basis. These studies introduced another strategy called small volume fluid resuscitation. Although studies were limited to animal model and some small clinical trials, they showed promising result for small volume fluid resuscitation. Small volume fluid resuscitation could reduce the additional blood loss due to continued bleeding or re-bleeding and lower mortality rate. Small volume fluid is an appropriate option in resuscitating patients especially those with uncontrolled hemorrhage.

Key words: fluid resuscitation, small volume resuscitation, controlled resuscitation, permissive hypotension

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Resusitasi Cairan Volume Kecil pada Syok Hemoragic: Latar Belakang Sejarah dan Ilmiah

ABSTRAK

Pendarahan merupakan penyebab kematian utama pada trauma. Kematian dapat dicegah bila pendarahan dapat dihentikan dan kehilangan darah dapat digantikan dengan cairan. Resusitasi cairan terbukti dapat memperbaiki perfusi jaringan dan mengembalikan kerusakan serta pembengkakan sel yang terjadi akibat pendarahan. Resusitasi cairan juga dapat menekan kadar sitokin yang dapat menyebabkan gagal organ multipel pada syok hemoragik. Metode resusitasi cairan yang dilakukan selama ini mengacu pada pedoman resusitasi *American College of Surgeon*. Meskipun telah luas diaplikasikan, beberapa penelitian melaporkan adanya bahaya dan mempertanyakan dasar ilmiah pedoman resusitasi tersebut. Penelitian tersebut memperkenalkan pilihan resusitasi lain yang disebut resusitasi cairan volume kecil. Resusitasi cairan volume kecil mengurangi risiko pendarahan lebih lanjut akibat pendarahan yang berkelanjutan atau pendarahan ulang dan menekan angka kematian. Oleh karena itu, resusitasi cairan volume kecil merupakan pilihan yang lebih tepat untuk meresusitasi pasien terutama pada pasien yang perdarahannya sulit dikendalikan.

Kata kunci: resusitasi cairan, resusitasi volume kecil, resusitasi terkontrol, hipotensi permisif

Introduction

Trauma remains major health problems both in high and low to middle-income countries. It is the most common cause of death in high-income countries and second most common cause of death in low to middle income countries only after infection.[1] It is estimated that 16 000 people die due to trauma per day.[1] Among them, 30-50% are the results of hemorrhagic shock.[2]

Fluid resuscitation is the mainstay of therapy for hemorrhagic shock.[3] It improves tissue perfusion, and restores cellular injury and edema in hemorrhagic shock. It also depresses level of multi organ failure causing cytokines.[4]

American College of Surgeon published a guideline in fluid resuscitation.[3] This guideline has been accepted worldwide, including in Indonesia. However, some authors now questioned the scientific background of the guideline and reported the jeopardy in applying it.[5-8]

As an alternative, they suggested resuscitation using small volume of fluid. This article reviews the historical and scientific background of small volume fluid resuscitation.

History of fluid resuscitation

While fluid resuscitation has been introduced since 19th century, it has not gained popularity until the end the first world war. During the world war, it was only known that delayed in definitive surgery to stop bleeding would increase the risk of dead.[9]

Year 1918 was the start of historical milestone for fluid resuscitation. In that year, Walter Canon reported that in order to treat shock, procedures to restore normal and stable blood flow were obligatory.[10] Those procedures included rapid bleeding control and blood loss replacement.[10] In the same year, he reported that blood replacement before adequate bleeding control would deteriorate bleeding. He recommended that resuscitation should not exceed 70 to 80 millimeter mercury of systolic blood pressure if the bleeding could not be controlled.[11]

During the second world war (1939-1945), Beecher applied the resuscitation principle of Canon.[11] He ob-

served that using the principle, none of his patients died due to uncontrolled bleeding. He used plasma or serum to replace the blood loss and considered saline or glucose to be inappropriate fluid replacement due to their rapid escape from intra vascular.[12]

In 1960 however, the resuscitation principle of Canon was abandoned. Studies in animal found that lowest mortality in hemorrhagic shock was achieved using large volume of crystalloid, equal to three times the volume of blood loss.[12] It should be noticed that hemorrhagic shock in those animal models were achieved by introduction of intravenous catheters, after which were closed by stoppers to prevent further bleeding.[13]

The concept of large volume crystalloid replacement was adopted during Vietnam war (1959-1975). It succeeded in lowering the incidence of acute kidney failure although the incidence of pulmonary shock, an entity known later as acute respiratory distress syndrome, exploded. Although the pulmonary shock was first believed to occur due to excessive crystalloid replacement, it was not proven in meta-analyses.[12,14,15] Thus, the concept of large volume crystalloid replacement resumed.

The guideline of fluid resuscitation by American College of Surgeon is partly, if not merely, based on the concept of fluid resuscitation using crystalloid. It recommends that as much as two liter of crystalloid should be given using two large bore intravenous catheters rapidly.[16] Additional fluid could be given according to hemodynamic responses until normal blood pressure is achieved. Transient response patients in hemorrhagic shock class II and III, and unresponsive patients in hemorrhagic shock class III and IV usually necessitate additional fluid.[16]

Scientific background of small volume fluid resuscitation

In 1991, Bickell[5] reported that poor effect would be resulted if traditional fluid resuscitation was applied in cases in which the hemorrhage was not massive. Volume as much as three times of blood loss would result in more prominent bleeding and higher mortality rate in first hour of resuscitation. The mortality rate was 100 % in resuscitation group compared to zero percent in group who did not received resuscitation.

The report of Bickell motivated other authors to question the rationality of large volume crystalloid replacement. They found that lack of randomized clinical trial were evident to support the resuscitation concept. Moreover, animal model used in the studies that support large volume resuscitation was not representative. In the model, rapid definitive bleeding control could be achieved by closing the catheter.[13] The model differs significantly from actual patient whose bleeding often cannot be adequately controlled.[13]

Studies have focuses to find more representative model in which the hemorrhage is difficult to control such as large vessel injury or abdominal trauma.[6-8] Stern, *et al.*[7] introduced aortic injury in pig and found that more bleeding and higher mortality resulted in group resuscitated to mean artery of 80 millimeter mercury compared to group resuscitated to 40 and 60 millimeter of mercury. Sindilinger, *et al.*[6] used resection of tail in rodent to achieve representative model and found more bleeding occurred in group treated with 80 mL/kg body weight of fluid compared to group treated with 40mL/kg body weight. Larger volume will cause re-bleeding due to dissipation of clot and dilution of clotting factors.[11,17-19] Sonden, *et al.*, cited from Holcomp,[11] showed that re-bleeding would occurred at 94 ± 3 millimeter mercury of systolic blood pressure, irrespective of size of defect in aorta.

In addition to more bleeding, studies have proven that aggressive fluid resuscitation will lower the core temperature and cause visceral edema, abdominal compartment syndrome, intracranial hypertension, extravascular fluid accumulation in the lung, as well as increasing mortality.[11,17-19]

On the other hand, Ley, *et al.*[20] in their prospective cohort of 3137 patients found that fluid volumes of 1.5 liter or more were significantly associated with mortality in both elderly and nonelderly patients. In patients

receiving fluid up to one liter, no significant increase in mortality was found. Morrison, *et al.*[21] in a randomized clinical trial involving 90 patients found that patients resuscitated to 55 millimeter mercury received significantly less blood products and total intra venous fluid during intraoperative resuscitation than those resuscitated to 65 millimeter mercury. Patients resuscitated to 55 millimeter mercury also had significantly lower mortality in the early postoperative period and a nonsignificant trend for lower mortality at 30 days.

Based on those studies, permissive hypotension concept as introduced by Canon has now regained its popularity. This concept utilizes small volume of fluid to restore circulation with minimal elevation of blood pressure to minimize re-bleeding. Despite the controversy of type of fluid to be used, permissive hypotension aims to achieved mean arterial pressure of up to 60 millimeter mercury.[16] Mean artery pressure of 60 millimeter mercury is sufficient to preserve organ perfusion while avoid re-bleeding.[16]

Conclusions

Recent evidences support the application of small volume fluid resuscitation. The benefits of small volume fluid resuscitation is emphasized especially in cases where control of bleeding could not be achieved.

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