Electro-acupuncture Stimulation at Acupoints Reduced the Severity of Hypotension During Anesthesia in Patients Undergoing Liver Transplantation

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Abstract

Background: Patients with end-stage liver diseases who undergo liver transplantation may suffer from hypotension related to the liver disease itself or related to the surgical procedure. Because electro-acupuncture (EA) at the Neiguan (PC-6) and the Jianshi (PC-5) points influences hemodynamics, we hypothesize that electro-acupuncture at the traditionally used acupuncture points will reduce the severity of hypotension in patients who undergo liver transplantation.

Methods: Forty patients with end-stage liver disease who underwent orthotropic deceased donor liver transplantation were randomized into two groups. The norepinephrine (NE) group received norepinephrine as a vasoconstrictor, and the electro-acupuncture group received EA at the PC-5 and the PC-6 points for treatment of hypotension during anesthesia for the liver transplantation. The patients were monitored, during the three stages of liver transplantation by using hemodynamic parameters.

Results: During the three stages of liver transplantation, there were no significant differences in the hemodynamic measurements including the mean arterial pressure, heart rate and central venous pressure between the two groups (p > 0.05).

Conclusions: Electro-acupuncture at the acupuncture points reduced the severity and the incidence of hypotension during anesthesia for liver transplantation.

1. Introduction

Up to 70% of patients with end-stage liver disease develop a hyperdynamic state characterized by increased cardiac output and arteriolar vasodilation [1, 2]. Nitric oxide and guanosine cyclic monophosphate (cGMP) have been implicated as the causes of hypotension [3]. Liver transplantation represents the sole definitive treatment for
end-stage liver disease, and patients who undergo liver transplantation may suffer from hypotension related to the liver disease itself, or related to the surgical procedure. Furthermore, liver transplantation is one of the most stressful cardiovascular events that a patient with cirrhosis may undergo [4].

Acupuncture-based techniques have been used for treatment of postoperative nausea and vomiting [5], postoperative analgesia [6], and preoperative management of anxiety [7]. In animal studies, electro-acupuncture at the Neiguan (PC-6) and the Jianshi (PC-5) points influences vascular pressure responses and the cardiovascular sympathetic system [8,9].

We hypothesize that electro-acupuncture (EA) stimulation at the traditionally used acupuncture points will reduce the severity of hypotension during anesthesia in patients undergoing liver transplantation. Thus, the purpose of the present preliminary study is to test the effect of electro-acupuncture at the PC-6 and the PC-5 points on hypotension during anesthesia in patients who undergo liver transplantation.

2. Methods

From May 2010 to December 2010, a prospective, randomized study was performed on 40 patients with end-stage liver disease who underwent orthotopic deceased donor liver transplantation. After obtaining written informed consent, the patients were randomly and evenly allocated to two groups: the norepinephrine (NE) group and the electro-acupuncture group. Patients in the norepinephrine (NE) group received norepinephrine as a vasoconstrictor, while patients in the electro-acupuncture group received electro-acupuncture treatment during anesthesia.

The induction of anesthesia was accomplished with thio- pental, fentanyl, and midazolam. Pancuronium or atracurium was used for neuromuscular blockade. Ventilation was maintained with an air-oxygen mixture plus isoflurane. Fluids and packed cells were administrated to maintain the central venous pressure at about 10 cm H₂O and the hematocrits at about 30%. Calcium gluconate was used to correct for a low calcium (Ca²⁺) level. Cardiovascular function was monitored using an electrocardiogram, a radial artery catheter, and the central venous pressure via the right internal jugular vein. Transplantation of the graft was performed using the piggy-back technique. The total ischemic time was defined as the period from the aortic cross-clamping and perfusion with preservation solution in donor to the completion of the anastomoses with portal reperfusion.

During the surgery, the patients in NE group whose mean blood pressure dropped to less than 60 mmHg, were given norepinephrine as vasoconstrictor with an initial dose of 0.05 mcg/kg/min; the dosage was increased until the mean arterial pressure (MAP) was maintained at more than 60 mmHg. For the EA group, we inserted sterile disposable acupuncture needles (diameter 0.25 mm and length 30 mm) in acupuncture points Neiguan (PC-6) and Jianshi (PC-5), as shown in Fig. 1. These points were selected based on the previous the studies and protocols of acupuncture therapy and are found to be 2 cun proximal to the crease of the wrist on the palmar side of the arm, between the tendon of the long palmar muscle and the radial flexor muscle of the wrist. Two needles were then connected to the EA system (model WQ-IOD1 multiple electronic acupuncture system, Beijing, China) and stimulation started with a dense-disperse frequency (f1:10 and f2:40) at an intensity of 4 mA, for all of the patients in this group. The intensity was then increased to 10 mA in some patients in order to maintain the mean arterial pressure above 60 mmHg. Because these patients were under general anesthesia, intensity of 10 mA did not hurt these patients. After that, the patients’ hands were covered by an operating room drape. In the NE group, the same needles were inserted at two nonacupoints of the patients’ shoulder, the wire of the EA system was connected to these needles without any stimulation, and then the area was covered with an operating room drape to ensure the blindness of the study.

3. Statistics

All values were presented as means ± SD and p < 0.05 was considered significant in all statistical tests. A group size of at least 20 patients was needed to show a difference of 15 (SD 10) mmHg in the mean arterial pressure (MAP) with a significance level of 0.05 (α < 0.05) and a power of 80% (β < 0.20). The statistical analysis was performed using the Kruskal-Wallis test for discrete variables and continuous variables were compared by using the one-way analysis of variance (ANOVA) test.

4. Results

No significant differences were noted in the demographic data of the donors and the recipients (p > 0.05) (Tables 1 and 2) or in the graft factors between the acupuncture group and the NE group (p > 0.05) (Table 2).

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographics data in recipients group.</th>
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<tbody>
<tr>
<td></td>
<td>NE (n = 20)</td>
</tr>
<tr>
<td>Sex(M/F)</td>
<td>13/7</td>
</tr>
<tr>
<td>Age(year)</td>
<td>28 ± 5</td>
</tr>
<tr>
<td>MELD Score</td>
<td>20 ± 5</td>
</tr>
<tr>
<td>Body Weight(kg)</td>
<td>51 ± 7</td>
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</table>

All values reported represent the mean ± standard deviation. NE, Norepinephrin. EA, Electroacupuncture.
patients with end-stage liver disease during the administration liver transplantation anesthesia. Patients with end-stage liver disease develop a hyperdynamic state characterized by increased cardiac output and arteriolar vasodilation [1,2]. The primary cause of low blood pressure in the patients with end-stage liver disease is vasoactive substances, such as nitric oxide and guanosine 3',5' cyclic monophosphate (cGMP) which bypass the normal hepatic metabolism [3].

During anesthesia for liver transplantation, many other factors add to the primary vasodilation as causes of hypotension. In the preanhepatic stage, in addition to the primary vasodilation, bleeding and drainage of ascites are major causes of hypotension. Moreover mobilization of the liver sometimes causes short duration hypotension [10]. In the anhepatic stage, cross-clamping of the suprahepatic and infrahepatic vena cava (IVC) which decreases venous return by as much as 50%, is a cause of hypotension [11,12]. Furthermore, in the neohepatic stage, reperfusion of the new liver through the portal vein is associated with an increase in preload but abrupt increases in the potassium and the hydrogen ion concentrations can cause decreases in the systemic vascular resistance and the blood pressure [13,14].

During anesthesia for liver transplantation, vasoconstrictors like vasopressin, and norepinephrine are usually used in order to treat the hypotension resulting from the primary vasodilation; however, they have some complications [15]. Norepinephrine seriously lowers the splanchic blood flow, but in some cases, it may reverse hepatorenal syndrome [16]. Vasopressin sometimes causes severe cardiac complications sometimes, and can be fatal in 5% of the patients [17].

In the present study, other causes of hypotension that resulted from the primary vasodilation were controlled during anesthesia. Hypotension that resulted from bleeding, drainage of ascites and cross-clamping of the suprahepatic and infrahepatic vena cava (IVC) was corrected by maintaining the central venous pressure (CVP) at

<table>
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<th>Table 2 Demographic data in donor group.</th>
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<tr>
<td>NE(n = 20)</td>
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<tr>
<td>Sex(M/F)</td>
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<tr>
<td>Donor Age(year)</td>
</tr>
<tr>
<td>Fatty change liver(%)</td>
</tr>
<tr>
<td>Graft weigh/recipient weight</td>
</tr>
<tr>
<td>Total Ischemic time(Hour)</td>
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</table>

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Also, no significant differences in the baseline mean arterial pressure, the baseline heart rate and the baseline central venous pressure were noted between the two groups (p > 0.05) (Table 3).

During the hepatectomy phase, the central venous pressures were similar between the two groups (p > 0.05) (Table 3). In this phase no significant differences in the mean arterial pressures, and the heart rates between the two groups (p > 0.05) (Table 3).

In the anhepatic phase, the central venous pressures were similar between the two groups and there were no significant differences in the mean arterial pressures and heart rates were noted between the two groups (p > 0.05) (Table 3).

In the neohepatic phase, the mean arterial pressures and heart rates were similar between the acupuncture and the NE group (p > 0.05) (Table 3). In this phase, the central venous pressures were kept similar between the two groups (p > 0.05) (Table 3).

5. Discussion

The present study showed that the electro-acupuncture at acupuncture points reduced the severity of hypotension in patients with end-stage liver disease during the administration liver transplantation anesthesia. Patients with end-stage liver disease develop a hyperdynamic state characterized by increased cardiac output and arteriolar vasodilation [1,2]. The primary cause of low blood pressure in the patients with end-stage liver disease is vasoactive substances, such as nitric oxide and guanosine 3',5' cyclic monophosphate (cGMP) which bypass the normal hepatic metabolism [3].

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<table>
<thead>
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<th>Table 3 Hemodynamic data in both groups.</th>
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<tbody>
<tr>
<td>Base line</td>
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<tr>
<td>EA group MAP(mm Hg)</td>
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<tr>
<td>NE group MAP(mm Hg)</td>
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<tr>
<td>p-Value</td>
</tr>
<tr>
<td>EA group HR(beats/min)</td>
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<tr>
<td>NE group HR(beats/min)</td>
</tr>
<tr>
<td>p-Value</td>
</tr>
<tr>
<td>EA group CVP(cmH2O)</td>
</tr>
<tr>
<td>NE group CVP(cmH2O)</td>
</tr>
<tr>
<td>p-Value</td>
</tr>
</tbody>
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about 10 cm H2O. Also, prior to the reperfusion, acidosis (excess hydrogen ion concentrations) and hyperkalemia as probable causes of hypotension during reperfusion, were corrected.

Electro-acupuncture at acupuncture point is known to influence hemodynamics and cardiovascular sympathoexcitatory responses [18,19]. In addition, electro-acupuncture at the PC-6 point is known to increase the stroke volume and the cardiac output, to alleviate hemorrhagic hypotension [20]. Electro-acupuncture at the PC-6 point also augments sympathetic tone and improves the inhibited cardiovascular function [21]. Based on a study by Syuu et al [20], the mechanism for the antihypotension effect of PC-6 EA seems to be due to increased vasomotor and venomotor tones. As Arai et al [22] showed in their study, transcutaneous electrical nerve stimulation (TENS) at the traditional acupuncture points reduced the severity and the incidence of hypotension after spinal anesthesia in parturient. By this Arai et al [22] meant that TENS applied at the PC-6 and the PC-5 points might have augmented sympathetic tone and improved the cardiac function, as well as the vascular tone.

One of the limitations of the present study was the failure to clarify the effect of PC-6 EA on venomotor tone because of the risk of severe hypotension resulting from the clamping of inferior vena cava, the drainage of huge ascetics and sometimes severe bleeding, the central venous pressure being kept at about 10 cm H2O by transfusion of adequate amount of colloids and blood products. Thus, in the present study as in previous clinical studies, we postulate that the electro-acupuncture applied on the PC-6 and the PC-5 acupoints might have increased the vascular tone and alleviated the hypotension that resulted from vasodilation during anesthesia for liver transplantation.

In conclusion, electro-acupuncture on acupuncture points reduced the severity and incidence of hypotension during anesthesia for liver transplantation.

References