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The effects of transjugular intrahepatic portosystemic stent shunt on systemic cardiocirculatory parameters☆,☆☆

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ABSTRACT

Purpose: We aimed to evaluate the effects of transjugular intrahepatic portosystemic stent shunt (TIPS) on systemic cardiocirculatory parameters in patients treated with TIPS for portal hypertension–associated complications.
Materials and Methods: This prospective study was conducted in an intensive care unit of a German university hospital (October 2010–July 2013). We assessed hemodynamic parameters before and after TIPS placement using single-indicator transpulmonary thermodilution and pulse contour analysis. After exclusion of 5 patients treated with vasoactive agents during study measurements, 15 patients were included in the final statistical analysis.
Results: Transjugular intrahepatic portosystemic stent shunt induced a statistically significant decrease in portal pressure (median, 29 [25%-75% percentile range, 23-37] mm Hg before TIPS vs 21 [18-27] mm Hg after TIPS; $P < .01$) in parallel with a statistically significant increase in central venous pressure (10 [6-15] mm Hg before TIPS vs 13 [9-16] mm Hg after TIPS; $P = .01$), cardiac index (3.8 [2.9-4.6] L min^{-1} m^{-2} before TIPS vs 4.5 [3.8-5.4] L min^{-1} m^{-2} 14 hours after TIPS; $P = .01$), and stroke volume index (54 [42-60] mL/m^2 before TIPS vs 60 [47-63] mL/m^2 14 hours after TIPS; $P = .03$). Arterial blood pressure and systemic vascular resistance index were statistically significantly lower after TIPS.
Conclusions: Transjugular intrahepatic portosystemic stent shunt placement is associated with an increase in central venous pressure and an improvement of global blood flow (cardiac index and stroke volume index) in patients with portal hypertension.

1. Introduction

Transjugular intrahepatic portosystemic stent shunt (TIPS) is used in the treatment of portal hypertension–associated diseases such as bleeding from esophageal varices [1,2], renal failure (hepatorenal syndrome) [3], and hydropic decompensation (ascites) [4]. When performing a TIPS procedure in order to reduce the portosystemic pressure gradient, a transhepatic track from a hepatic vein to the portal venous system is established by placing a stent graft. By shifting blood volume from the splanchnic vasculature to the central circulation, TIPS reduces portal pressure and increases cardiac preload. However, concerns have repeatedly been raised that this TIPS-induced increase in cardiac preload might promote circulatory failure in cirrhotic patients [5–7]. Just contrary, we hypothesized—based on the results of a previous prospective exploratory study of our group [8]—that TIPS improves cardiocirculatory function in terms of increased blood flow in cirrhotic patients.

We therefore conducted this prospective confirmatory study to evaluate the effects of TIPS on systemic cardiocirculatory parameters in patients treated with TIPS for portal hypertension–associated complications.

2. Materials and methods

2.1. Study design and setting

This prospective study was conducted in an intensive care unit of a German university hospital (Klinikum rechts der Isar der Technischen

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Universität München, Munich, Germany) between October 2010 and July 2013. The university hospital's institutional review board approved the study protocol, and all patients or their legal representatives gave written informed consent. In patients with indication for TIPS, we performed measurements of hemodynamic and laboratory parameters at predefined time points during the peri-interventional phase (details see below) and extracted the patients' clinical and demographic parameters from the medical records.

2.2. Transjugular intrahepatic portosystemic stent shunt and determination of the portosystemic pressure gradient

After insertion of a 10-French introducer sheath in the internal jugular vein, the TIPS procedure was performed as described before with a commercially available set (TIPSS-100; William Cook Europe, Bjaeverskov, Denmark) [8,9]. As previously described [8], after the creation of an intraparenchymal track from the right hepatic vein to the right portal vein (or a branch of the right portal vein), an uncovered self-expandable stent (Wallstent-Uni Endoprothesis; Boston Scientific Corporation, Natick, Mass) was placed after balloon dilation (Fox Plus; Abbott Vascular, Beringen, Switzerland). Before and after the TIPS procedure, the portosystemic pressure gradient (portal pressure – central venous pressure (CVP)) was assessed. In 3 patients, the CVP assessed by the interventional radiologist before TIPS was not documented in the patient's charts. For statistical analyses, we therefore used the CVP determined in the intensive care unit directly before TIPS.

2.3. Assessment of hemodynamic parameters

Directly before the TIPS procedure (ie, before the transfer to the Department of Interventional Radiology) as well as 1 hour and about 14 hours after TIPS placement, advanced hemodynamic parameters were assessed using single-indicator transpulmonary thermodilution (TPTD) and pulse contour analysis (PiCCO system; Pulsion Medical Systems SE, Feldkirchen, Germany). For TPTD, a 15-mL bolus of ice-cold 0.9% saline was injected in the central venous circulation through a central venous catheter. Using a dedicated 5-French thermistor-tipped arterial catheter placed in the abdominal aorta through the femoral artery (Pulsiocath; Pulsion Medical Systems SE) and a hemodynamic monitor (PiCCO 2 or PiCCO plus; Pulsion Medical Systems SE), TPTD values were computed. For each TPTD variable, 1 TPTD measurement was determined by calculating the mean of 3 values obtained by 3 consecutive indicator bolus injections. Using TPTD and pulse contour analysis, we assessed the following hemodynamic variables: heart rate, systolic arterial pressure, diastolic arterial pressure, mean arterial pressure (MAP), cardiac index (CI), stroke volume index (SVI), global end-diastolic volume index (GEDVI; indexed to body surface area), extravascular lung water index (EVLWI); (indexed to predicted body weight), pulmonary vascular permeability index (PVPI), and systemic vascular resistance index (SVRI). In addition, cardiac power index was calculated as MAP × CI × 0.0022.

2.4. Determination of laboratory parameters

Directly before and the day after TIPS placement, basic laboratory parameters were determined including serum electrolytes (sodium, potassium), renal parameters (serum creatinine, blood urea nitrogen, cystatin C), hepatobiliary parameters (serum bilirubin, γ-glutamyl transferase, aspartate aminotransferase, alanine aminotransferase), coagulation parameters (prothrombin time, international normalized ratio), and blood count (leukocytes, hemoglobin, hematocrit, thrombocytes). We determined pro–B-type natriuretic peptide (proBNP) directly before, 1 hour after, and the day after TIPS placement. In addition, we measured levels of norepinephrine, epinephrine, plasma renin activity, aldosterone, and antidiuretic hormone directly before and the day after TIPS insertion.

2.5. Determination of the indocyanine green plasma disappearance rate

Directly before and 6 hours after the TIPS procedure, the plasma disappearance rate of indocyanine green (ICG-PDR) was performed using a liver function monitoring system (LiMON; Pulsion Medical Systems SE), as described in detail before [8].

2.6. Statistical analysis

To describe the location and variability of continuous variables, we calculated the median with interquartile range (ie, 25%-75% percentile range). For qualitative data, we present absolute frequencies and relative frequencies in percentages. To compare variables before and after TIPS insertion in individual patients, we performed the nonparametric Wilcoxon rank sum test for paired measurements. For descriptive comparison of hemodynamic parameters before TIPS and 14 hours after TIPS, box plot figures displaying median and interquartile range of CI, SVI, MAP, and SVRI are shown.

Statistical tests were conducted 2 sided, and a P value less than .05 was used to indicate statistical significance. Statistical analysis was performed using IBM SPSS Statistics 21 (SPSS Inc, Chicago, Ill).

3. Results

3.1. Patients

We included 20 patients in this study. Because the treatment with vasoactive agents (eg, norepinephrine and terlipressin) during study measurements could have markedly altered hemodynamic and laboratory parameters analyzed in this study, we excluded 5 patients treated with vasoactive agents at any time point during study measurements. Therefore, 15 patients (12 male, 3 female) were included in the final statistical analysis. Patients had a median (25%-75% percentile range) age of 62 (58-68) years, a median height of 173 (169-178) cm, and a median actual body weight of 86 (75-100) kg.

3.2. Transjugular intrahepatic portosystemic stent shunt and portosystemic pressure gradient

The indication for TIPS was hepatorenal syndrome in 6 patients, refractory ascites in 6 patients, and variceal bleeding in 3 patients. The final TIPS diameter was 8 mm in 7 patients, 8.5 mm in 1 patient, 9 mm in 5 patients, and 10 mm in 2 patients. Transjugular intrahepatic portosystemic stent shunt placement induced a statistically significant decrease in portal pressure (29 [23-37] mm Hg before TIPS vs 21 [18-27] mm Hg after TIPS; $P < .01$) in parallel with a statistically significant increase in CVP (10 [6-15] before TIPS vs 13 [9-16] mm Hg after TIPS; $P = .01$). This resulted in a statistically significant reduction of portosystemic pressure gradient (18 [16-23] mm Hg before TIPS vs 10 [7-12] mm Hg after TIPS; $P < .01$).

3.3. Effects of TIPS on hemodynamic parameters

Hemodynamic parameters including TPTD- and pulse contour analysis–derived variables before, 1 hour after, and 14 hours after TIPS are shown in Table 1. Compared with baseline, CI and SVI were statistically significantly higher 14 hours after TIPS, whereas arterial blood pressure and SVRI were statistically significantly lower (Fig. 1). No TIPS-induced statistically significant changes in the volumetric cardiac preload parameter GEDVI and EVLWI (reflecting pulmonary hydration) were observed.

The median proBNP level before TIPS was 1673 (695-12 021) pg/mL. One hour and 14 hours after TIPS, we observed median proBNP levels of 1208 (326-10 161) pg/mL ($P = .18$ compared with baseline) and 1957 (641-8007) pg/mL ($P = .88$ compared with baseline), respectively.

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