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ORIGINAL ARTICLE

Basic Study

Esophageal variceal pressure influence on the effect of ligation

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Abstract

AIM: To explore the effect of *in vitro* porcine esophageal variceal pressure on complete ligation degree for polycyclic ligators.

METHODS: An *in vitro* model of experimental porcine venous vessels was used to test various venous pressures. Three treatment groups were designated according to the preset pressure range: P1 = 25-30 cmH_2O; P_2 = 35-40 cmH_2O; P_3 = 45-50 cmH_2O. The effect of pressure on ligation was assessed and compared among the groups.

RESULTS: Complete ligation was achieved at a rate of 56.25% (18/32) in group P_1, 37.5% (12/32) in group P_2, and 33.33% (11/33) in group P_3 (χ^2 = 3.6126; P = 0.0573).

CONCLUSION: Higher variceal pressures impair the ligation completion rate. Therefore, measuring variceal pressure may help predict the effect of endoscopic ligation and guide treatment choice.

Key words: Endoscopic variceal ligation; Mold of animal; Variceal pressure

Core tip: This study aims to explore the factors influencing rebleeding after endoscopic variceal ligation, and provide the theoretic basis for prevention and reduction of rebleeding after the procedure.

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INTRODUCTION

An increase in esophageal variceal pressure is a key factor leading to vascular rupture bleeding. Therefore, the measurement of esophageal variceal pressure is of great significance to evaluate and predict the risk of hemorrhage. Our previous *in vitro* preliminary work utilizing experimental ligation has shown that the ligation degree significantly differs among groups with various diameters of esophageal varices[1,2], though these experiments lacked evaluation of vascular pressure effects on the polycyclic ligator. Therefore, the aim of the present follow-up study was to explore the factors influencing rebleeding after endoscopic variceal ligation (EVL), in order to provide a theoretic basis for prevention and reduction of post-procedure rebleeding.

MATERIALS AND METHODS

Instrumentation and equipment

General surgical instruments were used in the procedures, including multi-band-ligators (Boston Scientific Corporation, Marlborough, MA, United States), glass column burettes, three-way stopcocks, and sodium chloride methylene blue solution. An Olympus GIF-Q260 gastroscope (Olympus Corporation, Tokyo, Japan) with a main engine and aspirator was also used.

Constructing venous pressure model from in vitro porcine vein vessels

The piglets were sacrificed, and exploratory laparotomy was performed to select the inferior vena cava, portal vein, and superior mesenteric vein as previously described[2]. Three pressure groups were included in the *in vitro* study: group P_1: 25-30 cm H_2O; group P_2: 35-40 cm H_2O; and group P_3: 45-50 cmH_2O. The "0" point of the liquid level in the glass burette was calibrated before each reading (Figure 1).

Making the in vitro porcine esophageal varices model

The piglet was sacrificed, the chest cavity was opened, and a section the esophagus (40 cm long) was removed and divided into three segments. The esophageal inner membrane was inverted, and a blunt dissection of the submucosal soft tissue was performed with hemostatic forceps, forming the porcine esophageal submucosal tunnel (Figure 2). Hemostatic forceps were used to pull one end of a porcine vein through the esophageal submucosal tunnel, creating the model of esophageal varices with different pressures.

Figure 1 Measuring venous pressure.

Figure 2 Established submucosal tunnel.

In vitro ligation model of pig esophageal varices and judgment of the effect

A Speedband Super 7 multiple band ligator was mounted on an Olympus upper endoscope aimed at a varicose vein with continuous negative pressure suction (0.03-0.05 MPa)[3]. When the endoscopic view was completely blue, the bands were released at the handle, the negative pressure suction was stopped, and a rubber band was firmly ligated on the lesion base[4]. After cutting off the esophageal mucosa after band ligation, the submucosal ligated varix was stripped, and the effect of endoscopic variceal ligation was observed: complete ligation (100%) the ligation effect is reliable and complete, and bands do not easily fall off; partial or incomplete ligation (50%) indicates that the ligation effect is not reliable, and bands can fall off early; no ligation (0%) indicates that the ligation failed, and esophageal varices were not ligated (Figure 3).

Statistical analysis

SPSS 13.0 software (SPSS Inc., Chicago, IL, United States) was used for data management and statistical analysis. Using the linear trend χ^2 test, $P < 0.05$ was considered as statistically significant.

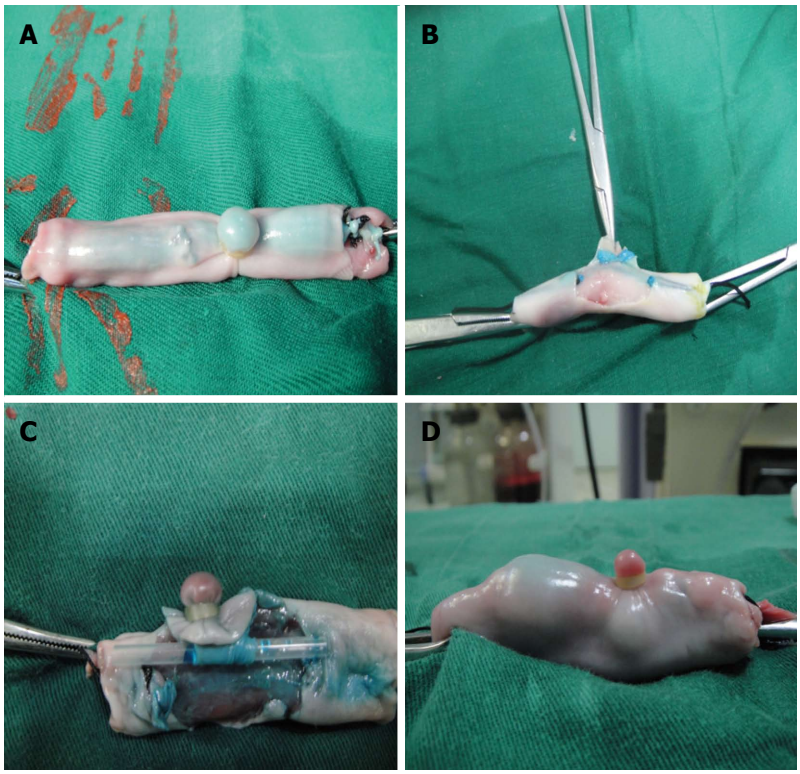

Figure 3 ***In vitro*** **ligation model of pig esophageal varices and judgment of the effect.** A: Ligation model; B: Complete ligation (100%); C: Partial ligation (≤ 50%); D: No ligation (0%).

RESULTS

A total of 97 *in vitro* models of esophageal varices were included in the study. For group P_1, complete ligation was achieved 56.25% (18/32), whereas 6.25% (2/32) showed incomplete ligation and 37.50% (12/32) showed no ligation. In group P_2, 37.50% (12/32) showed complete ligation, 12.50% (4/32) showed incomplete ligation, and 50.00% (16/32) showed no ligation. In group P_3, complete ligation was achieved in 33.33% (11/33), incomplete ligation was observed in 3.03% (1/33), and 63.64% (21/33) showed no ligation. Univariate analysis revealed that variceal pressure is an interference factor in predicting the degree of ligation (χ^2 = 3.6126, P = 0.0573).

DISCUSSION

Interest in esophageal variceal manometry has been increasing in recent years[5]. This study indicates that variceal pressure, rather than hepatic venous pressure gradient, may more directly predict the risk of bleeding, as measuring esophageal variceal pressure is particularly important for determining the effect of bleeding prevention and treatment[6-9]. Nevens *et al*[10] reported that variceal pressure is the most important predicting index of bleeding.

Normal portal vein pressure is 13-24 cmH_2O (1.27-2.35 kPa), when portal hypertension occurs, the pressure can increase to 30-50 cmH_2O (2.94-4.90 kPa). When the pressure exceeds 25 cmH_2O (2.45 kPa), gastroesophageal varices are prone to rupture and hemorrhage. Currently, endoscopic sclerotherapy and ligation are the primary methods for treating variceal bleeding, which can be effective for emergency hemostasis and occlusion of varicose veins, though some patients still exhibit recurrent bleeding. Portal pressure and hepatic venous pressure gradient do not correlate well and do not accurately predict variceal bleeding[11,12]. Whether intravariceal pressure influences the effect of variceal ligation and correlates with the other suggested endoscopic predictors is not clearly known.

The purpose of the current study was to explore the hemostatic effect after EVL in an effort to reduce the incidence of rebleeding and improve the outcome from esophageal varices rupture or hemorrhage. Rebleeding after EVL may occur because the variceal surface of band ligation is not strong, which can easily lead to band dropping off early. Strict control of EVL indications and contraindications will help to reduce the incidence of postoperative bleeding. Moreover, gastroesophageal varices are significantly related with portal pressure; the higher the portal pressure, the more serious the esophageal gastric varices[13], and increased portal pressure is a necessary prerequisite for esophageal variceal bleeding. A highly significant positive correlation was seen between variceal pressure and bleeding, indicating that patients with higher pressures bled more often. Intravariceal pressure was the most important variable in predicting variceal bleeding[14,15].

The experiments in the current study demonstrate that venous pressure parameter variation in the model is similar to that in humans[16]. We found that when the variceal pressure is within range of 25-30 cmH_2O, the rate of complete ligation is the highest, whereas the efficacy is reduced with increasing pressures. Although the results did not achieve statistical significance, the marginal *P* value (*P* = 0.0573) indicates that venous pressure might be an interference factor in predicting the degree of complete ligation. Additional studies with larger sample sizes are needed to further confirm these findings. Therefore, the search for the mechanisms of variceal rupture and the factors influencing variceal bleeding continues[17-29]. In other words, there are other variables influencing variceal bleeding, such as the thickness of the variceal wall; the wall tension increases disproportionate to the rise in pressure in blood vessels[30]. This is because a rise in the pressure causes an increase in the radius and a decrease in the wall thickness[31]. Thus, measuring variceal pressure is expected to be helpful in correctly predicting the effect of variceal ligation; however, investigation of other variables influencing the effect of EVL should continue.

COMMENTS

Background

Endoscopic variceal ligation is the primary method for the treatment of esophageal variceal bleeding. However, the effect of ligation on hemostasis in acute bleeding from esophageal varices was not been thoroughly investigated. The main problem for ligation in acute esophageal variceal bleeding is the accumulation of large amounts of blood in the gastrointestinal lumen, which may obscure endoscopic visualization. Therefore, the aims of this study were to understand the impact and the role of different degrees of variceal pressure on achieving complete ligations.

Research frontiers

Using porcine veins and esophagus, *in vitro* ligation of esophageal varices, is an innovative method to evaluate efficacy of variceal ligation treatments.

Innovations and breakthroughs

This study evaluated porcine esophageal variceal pressure and complete ligation degree using an animal model to guide endoscopic variceal treatment. The article has better practicability, and there are currently no relevant reports.

Applications

Variceal pressure may provide a valuable predictor for variceal bleeding following endoscopic variceal ligation.

Peer-review

This manuscript about esophageal variceal pressure influence is very interesting. In this manuscript, the authors explored the effect of *in vitro* porcine esophageal variceal pressure on complete ligation degree for polycyclic ligator. Three groups were studied. The results are interesting. Based on the results, the authors concluded that when variceal pressure is higher, the effect on ligation is worse.

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