



## Inferior Vena Cava Repair Using Serosal Patch of Small Bowel: An Experimental Study

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### ► ABSTRACT

**Objective:** To evaluate the feasibility and results of using serosal patch of small bowel for repair and replacement of inferior vena cava (IVC) after resection of a part of infra-renal IVC in an animal model, as it may be encountered in extensive tumors of retroperitoneal and trauma patients.

**Methods:** Five healthy sheep of both sexes were prepared. After general anesthesia and laparotomy, a defect with 1 cm width and 4cm length was made on anterior aspect of infra-renal IVC, and then an adjacent loop of small bowel was brought and sutured continuously to cover the defect of IVC as a patch graft. The observation period was two months.

**Results:** Three of five IVCs were macroscopically patent without stenosis and thrombosis. Pathologic assay revealed complete endothelialization of serosal surface of the patch of small bowel loop. One of IVCs was completely occluded in gross evaluation and fibrous formation in pathologist review. The sheep had no sign of venous hypertension and edema of limbs. One sheep died at the night of first operation due to internal bleeding.

**Conclusion:** Serosal patch of small bowel is an accessible and feasible alternative in repair and reconstruction of IVC especially when there is restriction for use of prosthetic material in a contaminated space of abdomen.

**Keywords:** Inferior vena cava; Small bowel; Patch; Repair; Reconstruction.

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### Introduction

Inferior vena cava (IVC) the largest vein in the body carries blood from the lower half of the body to the right side of the heart VC may be injured or need to be resected when it is encased by a large malignant

tumor during oncosurgery of retroperitoneal masses, renal cell carcinomas, metastatic liver resections or liver transplants [1,2]. It also may need to be repaired or reconstructed in, trauma patients. The primary repair, end to end anastomosis, graft interposition with autogenously or synthetic materials or endovascular

stent graft should be considered in selected cases. However, in cases the synthetic graft was preferred, intestinal contaminations due to small or large bowel perforation accompanying the trauma, have been cited as a limiting factor for the use of such grafts [3]. There are controversies about repair and reconstruction of IVC vs. primary closure of it [4]. Choice of conduit, autogenic vs. synthetic, and source of autologous conduit, pericardium, great saphenous vein, internal jugular vein or peritoneum, all are open subjects for more future studies [5-8]. Allogenic venous grafts and commercially available endografts have been used for reconstruction of IVC [9,10].

The results of reconstruction of IVC and its patency are very important in prognosis of the patient and alleviating the risk of hepatic and renal failure, ascites and lower extremity edema [11]. Use of prosthetic conduit-type polytetrafluoroethylene as alternative to autologous vein graft for reconstruction of the IVC is controversial. It may increase the chance of infection, bleeding, and thrombosis, but it has its proponents [12]. Reconstruction of the IVC has also been achieved using great saphenous vein spiral tube graft [13,14]. A review of the literature showed that serosal patch of small bowel has not previously been used as a patch graft for reconstruction of IVC. Compared to prosthetic materials, autologous options probably have a lower rate of infection and thrombosis in such a low-pressure system. If the small bowel patch graft shows good result in patency of IVC, then it could be a very interesting alternative for surgeons, because of availability and decrease in the time required for operation in such complicated and time consuming procedures.

## Materials and Methods

### Animals

The ethics committee and the institutional review board (IRB) of Shiraz University of Medical Sciences

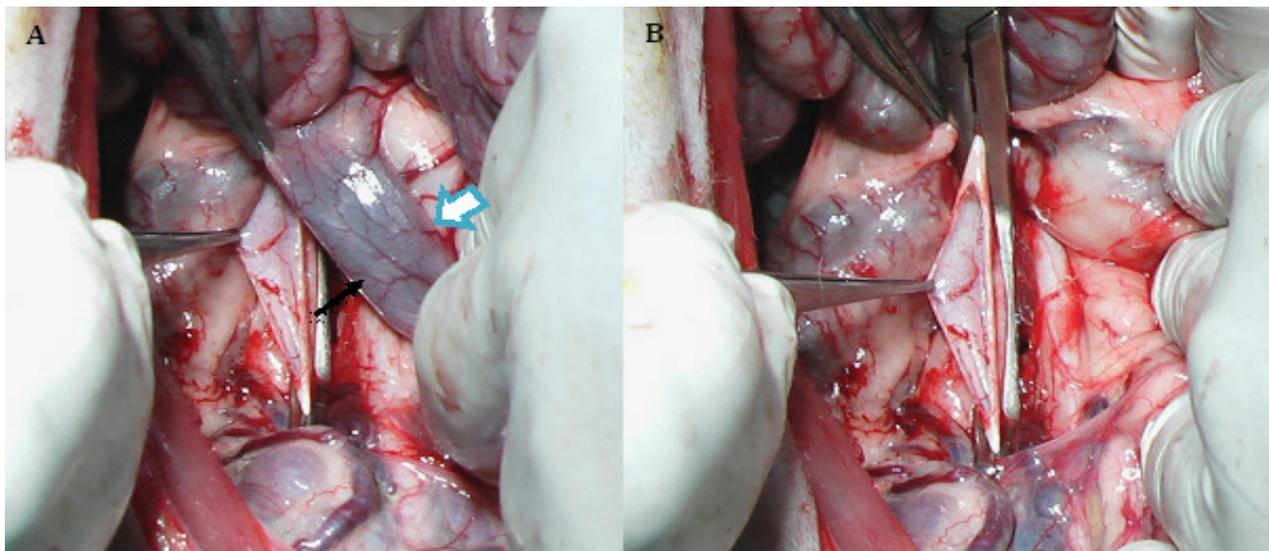
approved the study protocol. Five healthy sheep (25-30 kg weight) of both sexes were obtained from the Animal Breeding Center (Shiraz University of Medical Sciences). They were observed for one week for health evaluation under observation of a veterinarian. They were then included in the study.

### Study Protocol

On the day of operation, they were anesthetized by intravenous administration of 3-5 mg/kg thiopental sodium (Pentothal, Abbott, and Stockholm, Sweden). Then they were tracheally intubated and were connected to ventilator. Anesthesia was maintained by halothane and oxygen. Afterward, an intravenous injection (30 mg/kg) of cephalotine (Jaberebne Hayyan, Tehran, Iran) was given. Surgery was done under standard sterile preparations. Through a midline peritoneal incision, the abdominal IVC, up to its bifurcation, was exposed, and the IVC was completely cross-clamped at 2 sites 5-6 cm apart. Anterior surface of infra-renal vena cava was resected for 4cm length. This segments were repaired by replacement of an adjacent small bowel loop serosal surface and it is anastomosed to IVC cut borders with continuous Prolene 4-0 sutures as a serosal patch graft (Figure 1). Local homeostatic care was applied, and the abdomen was closed. No additional antibiotics, antiplatelets, or anticoagulant agents were given during the postoperative period.

### Outcome Measures

Two months later, the sheep were anesthetized as described, next, an abdominal midline incision was made, and the grafted small bowel and IVCs were exposed and evaluated macroscopically for the patency and formation of pseudoaneurysm. The vena cavae were clamped, and the reconstructed segments with 2 cm of native IVC margins were removed. All the removed specimens were immersed in 10% buffered formalin for fixation. Several hematoxylin-



**Fig. 1.** Apposition of adjacent small bowel loop to inferior vena cava (IVC). **A:** The vena cava is clamed (black arrow) and a free loop of jejunum selected for use in caval repair (white arrow). **B:** Anterior wall of infrarenal IVC was resected and prepared for repair with serosal patch of small bowel.

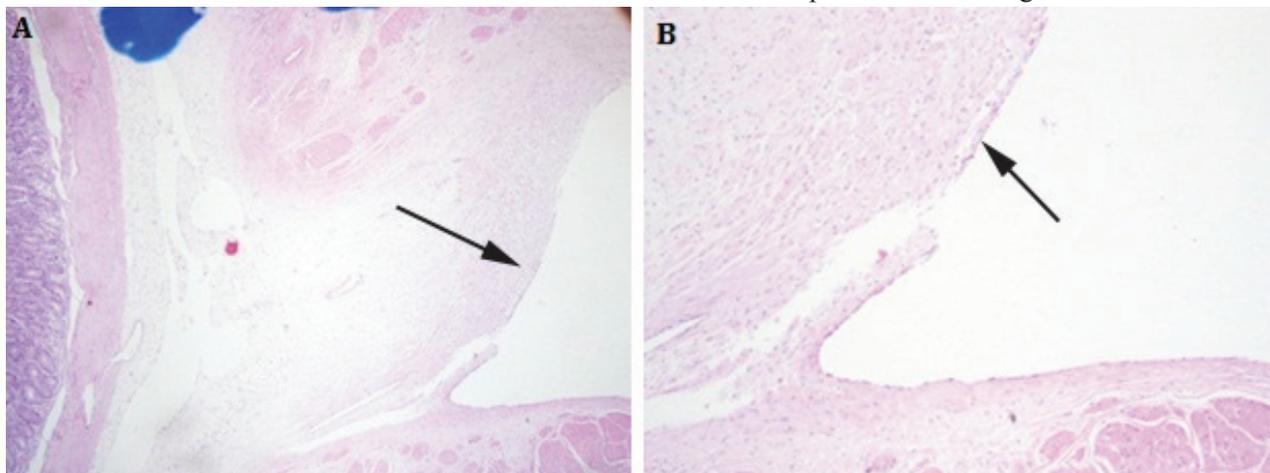
eosin-stained slides were prepared from the native IVCs, anastomotic sites, patch grafts, and examined microscopically.

## Results

Four of five sheep survived the operation (80%) and the subsequent observation period for two months. One of them died at the night of operation due to internal bleeding (20%). Afternoon of the day of operation they received oral fluid and then solid diet. None of the four survived sheep developed signs of obstruction and no edema of limbs was seen during the observation period. The wounds that were dressed for three days did not show signs of inflammation and infection in follow-up visits. Two months later the animals brought again to animal operation room, received general anesthesia and were explored for macroscopic evaluation of the target region and harvest of the reconstructed IVCs and associated small bowel loops. In exploration, there were some amounts of adhesion bands around the region of previous procedure. Macroscopic evaluation revealed no sign of collection and pseudoaneurysm formation (Figure 2). There was not any sign of venous engorgement and collateral formation in pelvic cavity. Infra-renal IVC including the grafted loop of small bowel was harvested and the sheep were sacrificed. Macroscopic evaluation of the lumen of the IVCs revealed that in



**Fig. 2.** Lumen of harvested patent inferior vena cava (IVC) in the region of small bowel serosal patch caval repair.



**Fig. 3.** Sections from the endothelialized grafted segment of inferior vena cava (IVC), with low (A) and high magnification (B). Small bowel mucosa is visible at both images (arrow) (Hematoxylin and eosin staining).

three of four samples, IVCs were patent without signs of thrombosis, stenosis and deformity (75%). Suture lines were intact and intraluminal serosal surfaces were soft and in gross, the surface had the appearance of other endothelial surfaces of IVC. One of IVCs was completely occluded but its intraluminal adhesions were loose and became open with gentle forceps manipulation. All four samples were fixed in formalin and sent for histologic assay.

## Histopathology Assay

Patency of lumens that was seen in gross examination was confirmed in microscopic histology. In three of four, the lumens were completely endothelialized on the seromuscular layer of small bowel in continuity with the adjacent three vessel layers. No thrombosis was seen in the target region and other sides of IVC lumens. Acute and chronic inflammation was present in neoendothelialized part of IVCs. Endothelialization was confirmed with immunohistochemistry assay (Figure 3). The one sample that IVC was obliterated in that also showed some pieces of new endothelial formation associated with fibrous tissue that made it occluded.

## Discussion

The search for an ideal substitute for segments of the venous system has led to numerous experimental and clinical studies using a wide variety of materials and techniques. They noted that, in general, autogenous vein is the only satisfactory inferior vena cava substitute. Subsequent experimental studies using a variety of synthetics including Gore-tex, woven silicone rubber, woven Teflon, and knitted or woven Dacron have not been uniformly successful [15]. Similarly, tissue substitutes including autogenous peritoneum, autogenous fibrocollagenous tubes, and bovine pericardium were used with variable results [6]. Now, that resection of extensive retroperitoneal sarcomas has become more common and more complex with increasing surgical expertise, it may be more important for the surgeon to have different

alternatives for either situation of inadvertent or intentional great vessels injury. Vena cava may also need to be repaired or reconstructed in trauma patients. The primary repair, end to end anastomosis, graft interposition with autogenous or synthetic materials or endovascular stent graft should be considered in selected cases [7,10].

When a surgeon encounters a penetrating trauma to abdominal cavity with stable retroperitoneal hematoma and infrarenalcaval injury, it is not uncommon that the vascular trauma be concomitant with bowel injury. Then he should go for repair of vena cava if could save the patient stable with perfect retroperitoneal exploration and proximal and distal vena cava control. Although, the surgeon may go for primary repair of sharply injured vena cava without significant defect, if the repair made it narrow, then he may go for ligation of vena cava with the acceptance of its probable complications. It needs more study about the possible intra-abdominal easily accessible alternatives for use in repair of vena cava, at least for damage control, like one that we assayed, serosal patch of small bowel, beside autogenous, biologic and prosthetic alternatives [16,17].

It was shown in the present study that small bowel serosal patches did not cause stenosis of the IVC in 3 of 4 sheep, even without postoperative administration of anticoagulant or antithrombotic drugs. This finding is similar to that of the study by Hodjatiet *al.* that used peritoneal flap and renal capsule patches for caval repair [8,18]. We have previously, used a tubular flap of parietal peritoneum to interpose a part of infrarenal IVC in a canine model, and with 8 of ten flaps were patent after two months [8]. In 2013, Hodjatiet *al.*, [18] designed an animal study to evaluate another option for vena cava repair, in that all ten canine vena cava repair with patches of renal capsule were patent without stenosis after three months.

A review of the published data showed that segments of autologous small bowel have not previously been used as a patch graft for IVC reconstruction. The present study has shown that serosal patch grafting of the IVC is technically feasible and is associated with complete intraluminal endothelialization of the graft. Although, taking the desired results in three of five animals may not be encouraging about safety of the method, but the novelty of idea has its value for doing more studies. As a whole, in this study we chose small bowel as a vascular graft because, mesothelial surface of small bowel has the same origin as the endothelium, and it have the property to inhibit thrombogenesis [8]. It also is readily available and does not needs any additional incision and it takes less time to repair an injured IVC. In the setting of a trauma patient or during a long operation for an extensive retroperitoneal tumor resection, saving time and making less injury by selecting an available safe option in abdomen is important for surgeon and patient. All of these, made small bowel serosal surface, an interesting alternative for more experiments, especially about partial IVC wall defects in trauma patients or retroperitoel mass surgeries.

In conclusion, the findings of the present preliminary experimental study have shown for the first time that small bowel serosal patch can be used for reconstruction of large veins in an animal model. The author's results may provide a basis for future research in this field. The authors studied using also renal capsule patch and peritoneal flap for IVC reconstructions. Serosal patch of small bowel can be an accessible and feasible alternative in repair and reconstruction of IVC especially when there is restriction for use of prosthetic material in a contaminated space of abdomen.

**Conflict of Interest:** None declared.

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