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Comparative Study between the Jejunum and Colon as Substitute for the Esophagus in Terms of Blood Flow

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The advantages over a substitute for attaining the continuity following resection of the esophagus were experimentally compared between the jejunum and the colon in terms of changes in blood flow in the vascular pedicles under the influence of mechanical tension, induced systemic hypoxia and hypotension. Blood flow of the pedicled jejunal and colonic grafts used were measured with the use of direct collection through catheter introduced to the pedicled vessel.

1) As for tension-load added to the pedicle, the colon was much more tolerable rather than the jejunum. When a 40g tension was added to the jejunum, blood flow was remarkably reduced whereas there was no significant change in the colon even when a 100g tension was added.

2) As for the influence of induced hypoxic load, blood flow to the pedicled grafts was reduced when the arterial Po_2 fell to below 70mg and Pco_2 over 50mg.

3) As for the influence of induced systemic hypotensive load, it was significantly reduced to below about 30% of the normal systemic blood pressure in the similar patterns between the jejunum and the colon.

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INTRODUCTION

Surgical treatment for esophageal disorders has been well established in accordance with advances in thoracic surgery. The most detrimental outcome following surgery, however, is not infrequently encountered in the incidence of postoperative complications such as anastomosis insufficiency and pneumonia. To prevent the accidental occurence of anastomosis insufficiency, surgeon should be aware of keeping an adequate blood supply in the esophageal substitutes without any tension. The gastric tube is more frequently used for esophageal substitute but either the colon or the small intestine may be candidate for replacement in patients with the stomach previously resected.

The aim of this study is to verify as to whether which of the two grafts is preferable as a substitute for the esophagus resected.

METHOD AND MATERIAL

Mongrel dogs weighing from 15 to 20 kg were anesthetized with 25 mg/kg of pentobarbital sodium, intubated with a cuffed endotracheal tube and ventilated with room air without humidification using a volume respirator (HARVARD).

Fifty mg of pentobarbital sodium was repeatedly given for permitting an adequately anesthetized state with time.

Laparotomy was made through middle abdominal incision. The jejunal graft was prepared for interposition between the thoracic esophagus as shown in Fig. 1. A 15cm jejunum, 5cm distant from the Treitz' band, was isolated leaving the third jejunal artery in spite of division of the first and second branches of the jejunal artesies as a mesenterial vessel stalk and a 10cm distal portion of isolated jejunum was sacrificed to draw up easily to the thoracic esophagus as drawn in Fig. 2.

It was difficult to identify the dog's colon from the ascending, transverse and discending colon in human being. A 8 cm middle portion of the colon was isolated with the vascular pedicle as shown in Fig. 3 and it was drawn up to the thoracic esophagus to be

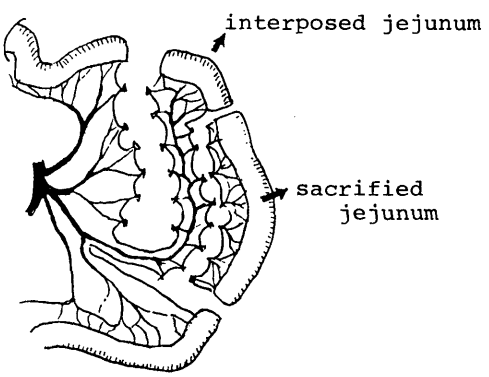

Fig. 1 The method of providing the interposed jejunal graft, a 15cm jejunum, 5cm distant from the Treitz' band, is prepared for interposed graft, leaving the third branch of the jejunal artery and sacrifying the distal jejunum of about 10cm long.

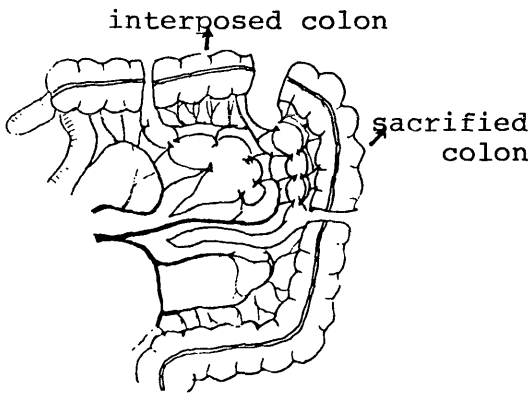

Fig. 2 The method of providing the interposed colonic graft with partially sacrified colon.

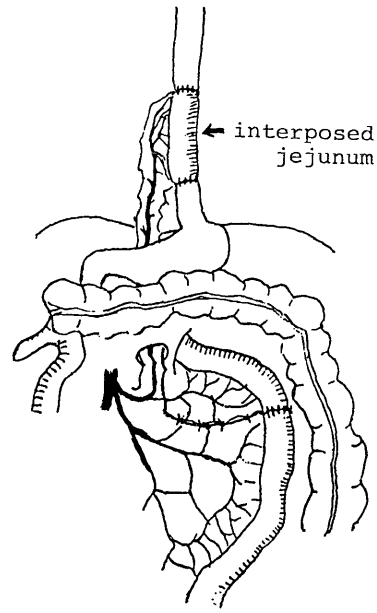

Fig. 3 The mode of reconstruction of the esophagus resected.

interposed as indicated in Fig. 1.

The blood flow to the colonic and jejunal grafts was measured with direct measurement of droplet through indwelling polyethyrneve catheter (2mm in diameter) into the mesenterial vein in 20 dogs. The blood flow was calculated as a ml/min/g-tissue. The arterial pressure was also monitored in the abdominal aorta through the catheter inserted in place with the use of Nihon Koden transducer (TP-101T) and the arterial pH, Po_2 and Pco_2 levels were checked using IL-meter.

The Blood flows to the grafts in the conditions of tension-load to the vascular pedicle and induced hypoxia or hyercapnia were experimentally compared between the jejunal and colonic grafts. Tension-load was added by means of drawing a greaft upwards, measuring with the spring scale.

Systemic hypoxia was provoked by changing the inspired 0_2 concentration. Hypoxia was produced with inhalation of a mixture of $95\%N_2$ and $5\%0_2$. The arterial Po_2 and Pco_2 were checked four times at interval of 5 minutes.

Furthermore, the influence of induced hypotension, by which 23 dogs were bled until the arterial pressure was reduced to 60mmHg level, was also assessed as to the changes in blood flow to the jejunal and colonic grafts.

RESULT

The changes in blood flow according to tension-load of 20, 40, 60, 80, and 100g added to the vascular pedicles were measured in the jejunal and colonic grafts.

Under the circumstance of free-tension, blood flow averaged 0.34 ml/min/g-tissue

in the jejunal graft in 10 dogs and averaged 0.46 ml/min/g-tissue in the colonic graft in 10 dogs. When tension was added, blood flow was reduced. It was significant at over 40g tension-load. When tension-load reached to 100g, the decreased rate of blood flow was 39% in the jejunal grafts whereas it was 5% in the colonic graft as shown in Fig. 4. When systemic hypoxia and hypercapnia were induced, blood flow to the jejunal and colonic grafts were also measured as indicated in Fig. 5 and 6.

Systemic hypoxia produced the decreased blood flow in both the jejunal and the colonic grafts. In the jejunal graft, it, however, was evident at below 70 mmHg of the arterial Po_2. While the arterial Po_2 values reached to 50 mmHg, the reduced rate in blood flow was 68% in the jejunal graft and 58% in the colonic one.

Blood flow in the jejunal and the colonic grafts were plotted according to the arterial Pco_2 levels as shown in Fig. 6. When the arterial Pco_2 level exceeded 50 mmHg, blood flow markedly decreased but it was not necessarily similar with the changes in the arterial

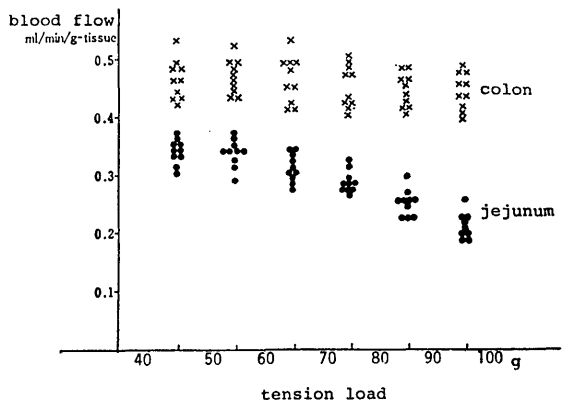

Fig. 4 Changes in blood flow in accordance with added tension load to jejunal and colonic grafts.

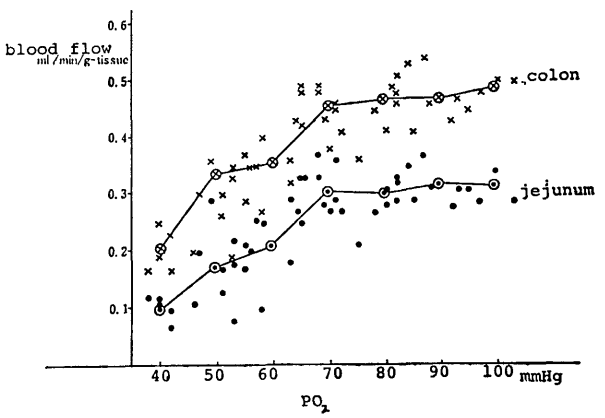

Fig. 5 Changes in blood flow in accordance with systemic hypoxemia in jejunal and colonic grafts.

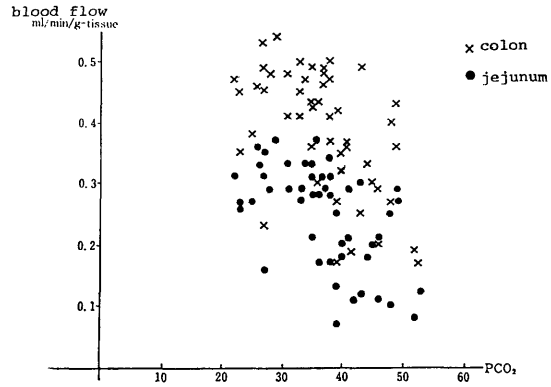

Fig. 6 Changes in bood flow in accordance with systemic hypercapnia in jejunal and colonic grafts.

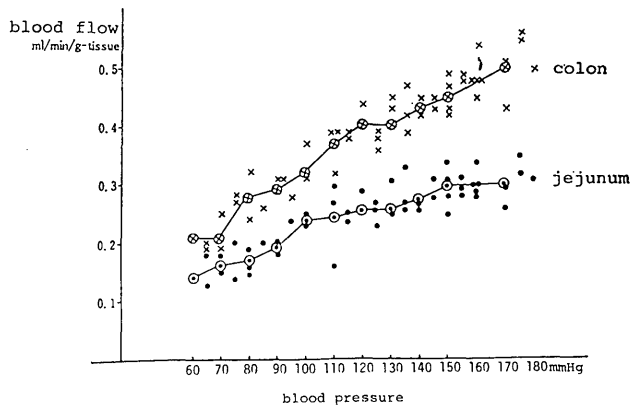

Fig. 7 Changes in blood flow in accordance with systemic hypotension in jejunal and colonic grafts.

Pco_2 levels.

Blood flow prior to induced hypotension during a period of 150 to 180 mmHg in systemic pressure showed 0.302 ml/min/g-tissue in the jejunal graft and 0.496 ml/min/g-tissue in the colonic graft.

When the systemic pressure level dropped to 60 mmHg, blood flow in the colonic graft was significantly reduced in comparision with that in the jejunal graft as shown in Fig. 7. The decreased rates of blood flow in the jejunal graft were 13% at 130 mmHg of systemic pressure and 20% at 110mmHg whereas those in the colonic graft were 13% at 130 mmHg and 26% at 110 mmHg respectively. Then, 20 to 30% drops in the systemic pressure allow blood flow to be reduced by 10 to 20% in the jejunal graft and 20 to 25% in the colonic graft.

DISCUSSION

Surgery for diseases of the esophagus is well developed. The operative outcome, however, is poor when postoperative complications would occur. One of the most detrimental complications is anastomosis insufficiency and its incidence is not so low in occurrence as reported by COLLIS[1] and POSTLETHWAIT[2] *et al.*. Anastomosis insufficiency is derived from tension-load in anastomotic site and the impaired blood supply as a local factor. To achieve the continuity following resection of the esophagus, the stomach, jejunum and colon were used as the reconstructive material.

The stomach[6][7] is widely accepted for this purpose but in patients with gastrectomy, either the jejunum[8][9] or colon[9][10] should be used. It is certain that the favarable blood supply in anastomotic site leads to an excellent healing. In this study, the changes in blood flow in the jejunum and colon drawn upwards to the mediastinum were experimentally evaluated to compare as to whether which of the two is resistent to the loads of tension and systemic hypoxia in terms of blood supply. In the assessment of wound healing process, it is noted that submucosal healing with complete adaptation of the mucosa plays an important role in providing the satisfactory healing[11]. Then, meticulous techniques in anastomosis as an operative procedure are required. To facilitate the healing process in anastomotic site, an adequate blood flow is needed under tension-free circumstance. On the basis of the results of biochemical consideration, fibroblast production is indispensable to give a better healing and it is facilitated by an excellent blood run-off without tissue anoxia[12]. As previously reported, it is important to avoid the reduction of blood flow in anastomotic site.

The superiority to overcome the accidental loads of tension and systemic hypoxia was compared between the jejunum and the colon in terms of blood supply. In our study, it was elucidated that there were large amounts of blood flow per tissue in the colon rather than in the jejunum and while tension would be added to the pedicle, the blood flow per tissue was significantly compromized in the jejunum rather than in the colon. When tension to the pedicle of the jejunum exceeds 40g, the blood flow levels were markedly reduced. Meanwhile the changes in blood flow in the colon were minimal even when tension reached to a 100g level. Blood pressure level was also influenced on blood flow in the jejunum and colon used for reconstruction of the esophagus. The changes of blood flow in the colon under the circumstances of hypotension were prominent rather than those in the jejunum.

It is likely that the influential factors on blood flow to the pedicled graft of the colon and jejunum, which are used as a substitute of the esophagus resected, are as follows, over 40g of tensile strength added to the pedicle, below 70mmHg of the arterial Po_2, over 50mmHg of the arterial Pco_2 and hypotension below 30% of the normal.

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