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Assessment of a gastric arterial network for oesophageal substitute by means of pulse oximetry

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Insufficient vascularisation of substitutes in the operative reconstruction of the oesophagus is one of the main causes of the occurrence of anastomotic leaks. In the present study, the blood oxygenation of gastric substitutes for the oesophagus was evaluated before and during the reconstruction. A pulse oximeter was used for the assessment (S&J Medico Teknik AIS, Albertslund, Denmark). Oxygenation in the examined places ranged from 79% to 98%. The values of blood oxygenation in places C1 (fundus of the stomach after the formation of the substitute) and C2 (fundus of the stomach after the formation and stretching of the substitute) were significantly lower than those in analogous places in the stomach before the transformation (C/C1 $p < 0.02$; C/C2 $p < 0.03$, Fisher test). There were no correlations between pulse oximetry values observed and the presence of anastomosis leak.

key words: oesophageal cancer, oesophageal substitute, oesophageal surgery, gastric pulse oximetry

INTRODUCTION

One of the most important stages of the operative reconstruction of the oesophagus consists in forming a substitute of the organ which would be long enough and have sufficient blood supply [1, 12]. The use of the stomach for this purpose is, in technical terms, the easiest way of replacing the oesophagus, particularly in cases of malignant neoplasm. The stomach is easy to mobilise, is well vascularised, has a well-developed intramural vascular network and is long enough to be carried as far as the neck [3, 7]. Owing to its anatomic conditioning, the organ may be used as a whole or in the form of a tube produced from its part on the side of the great curvature [9].

An anastomotic leak is a major surgical complication which occurs after partial resection of the oesophagus and oesophagogastric anastomosis [2, 4]. The complication markedly contributes to the occurrence of early and late stenosis in the anastomosis, and boosts postoperative mortality [2, 4]. These complications are mainly caused by insufficient circulation at the site of the anastomosis, ischaemia of the anastomosed tissues and a consequent disturbance of the healing process [10].

Pulse oximetry is a method widely applied in monitoring the oxygenation of the arterial vessels in anaesthetised patients. The appliance measures the percentage of the oxygenation of haemoglobin in a pulsating vascular bed [6].

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The aim of the study was to evaluate the usability of pulse oximetry in the assessment of the vitality of gastric substitutes for the oesophagus in patients undergoing partial resection of the oesophagus for squamous epithelial carcinoma.

MATERIAL AND METHODS

With a view to achieving the aim of the study, the vascular supply of 45 substitutes for the oesophagus was examined in patients who were operated on for squamous epithelial carcinoma of the thoracic section in the 2nd Department of General Surgery of the Medical University in Lublin between 1997 and 2000. They included 41 men and 4 women aged between 33 and 70 (58 on average). The neoplastic lesion in 27 (60%) cases was located in the middle section, whereas in the other 18 (40%) cases — in the lower section of the oesophagus. When assessing the clinical stage of the carcinoma development (pTNM), 7 (16%) patients were found to be in stage IIa, 11 (24%) — in IIb and 27 (60%) — in stage III of the carcinoma.

The same team of surgeons performed all procedures, consisting in oesophageal resection and substitution with a reshaped stomach. That is why the method of producing oesophageal substitutes was similar in all the cases. Using the abdominal cavity access, the stomach was mobilised as a reconstruction organ for the oesophagus. It was elongated by cutting off the lesser curvature using staplers. A possibly wide margin of the transverse ligament of the stomach was left on the side of the greater curvature. Short gastric vessels were ligated near the spleen hilus. The vascular network of the oesophageal substitute was built of the right gastric artery and the right gastro-omental artery. In 25 (56%) patients, the stomach, transformed in such a way, was carried through a tunnel behind the sternum up to the neck. In the other 20 (44%) cases, the substitute for the oesophagus was carried to the neck through the back mediastinum. In the posterior gastrooesophagostomy, interrupted sutures were done in two layers, while in the anterior gastrooesophagostomy — one layer of interrupted sutures was done all through the oesophageal and gastric wall. No pyloroplasty was carried out. In the postoperative course, a leak in the cervical anastomosis occurred in 4 (9%) patients with the stomach placed behind the sternum. Medical treatment was used to heal the fistulas.

Initially, before the oesophageal substitute was formed using a sterile probe of the pulse oximeter with flat endings (S&J Medico Teknik AIS, Albertslund, Denmark), oxygenation was recorded in the following places in the stomach: near the pylorus on the side of the greater curvature (point A), at half-length of the stomach on the side of the greater curvature (point B), at the end of the produced "tube" (point C) and near the pylorus on the side of the lesser curvature (point D — Fig. 1).

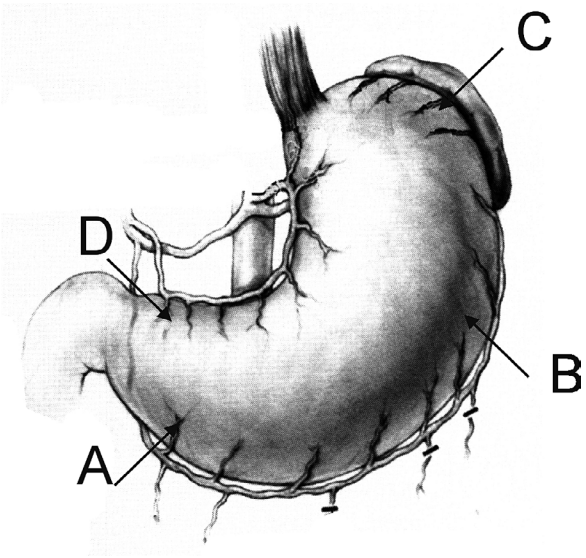

Figure 1. Picture of the stomach before forming the transplant. Points A, B, C, D — examined places of blood oxygenation.

After the substitute had been formed, it was loosely arranged on the chest and its vitality was clinically assessed. Attention was paid to the colour of individual parts of the stomach, occurrence of oedema and haemostasis in venous vessels. First of all, the arterial network and the furthest extent of vessel pulsation were evaluated. The type and intensity of bleeding (venous, arterial bleeding) along the suture lines on the lesser curvature of the stomach were also examined. The evaluation was repeated for analogous places in a loosely arranged transplant (points: A1, B1, C1, D1) and after extending the transplant to the cervical anastomosis (points: A2, B2, C2, D2 — Fig. 2).

In the readings of oxygenation of each examined point, the lowest, the highest and the mean values were recorded (Table 1). The Fischer test was used to compare the differences between the values of blood oxygenation in specific points, whereas Friedman's test and Kendall's coefficient of compatibility — ANOVA test — revealed individual differences in all the groups. On the seventh day after the anastomosis was carried out, an X-ray examination was performed on all the patients.

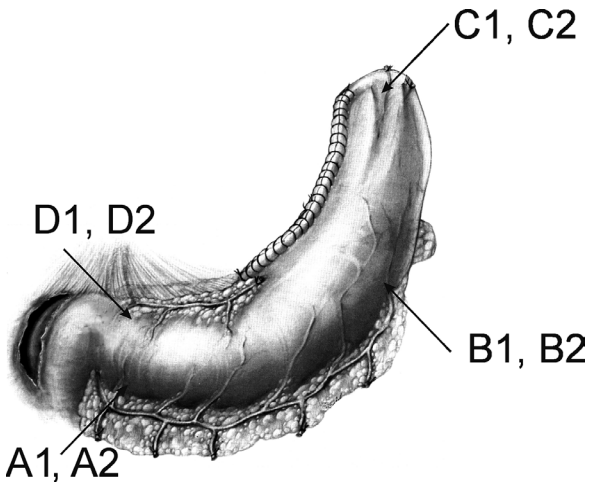

Figure 2. Picture of the stomach after forming (points A1, B1, C1, D1 — examined places of blood oxygenation) and after stretching the transplant (points A2, B2, C2, D2 — examined places of blood oxygenation).

RESULTS

When evaluating the macroscopic picture of the formed oesophageal substitutes, the presence of venostasis was observed (excessive filling of the venous vessels, oedema of the stomach wall, lividity of the serous membrane). The intensity of the described changes varied between substitutes. It was not possible to demonstrate the connection between the colour change, the oedema of the transformed stomach and oxygenation measured with pulse oximeter. The oxygenation of the arterial blood in the examined places varied considerably. The values range from 79% to 98%. The lowest values were observed in the fundus of the oesophageal substitute after stretching 79% to 91%, 85.2% on average (points: C1 and C2). It was also found that the difference between oxygenation in points C/C2 ($p < < 0.03$) was statistically significant (Fisher test). In other specified places no significant differences in the blood oxygenation of individual points were found ($p < 0.07$, ANOVA test) (Fig. 3). In the postoperative course, four fistulas were observed in the anastomosis. The obtained values of the oxygenation of the formed substitute before and after stretching were within the lower range in the case of one anastomotic leak only. In that case, the macroscopic picture of the "transplant" (oedema, lividity of the fundus, venostasis) indicated its poor vascularisation.

Table 1. Blood oxygenation values in the examined points throughout the stomach: A, B, C, D; after the transplant formation: A1, B1, C1, D1 and after the transplant stretching: A2, B2, C2, D2

Examined points	Value range (percentage)	Mean ± SD	p value (Fisher test)
A	87–92	89.2 ± 2.0	
B	86–94	91.75 ± 0.5	
C	86–94	89.0 ± 2.3	
D	89–92	91.0 ± 1.4	
A1	84–97	89.1 ± 3.8	p = 0.529
B1	86–98	91.5 ± 3.9	p = 0.076
C1	87–91	88.8 ± 1.6	p = 0.071
D1	88–95	92.6 ± 3.1	p = 0.237
A2	86–96	88.7 ± 3.2	p = 0.102
B2	87–91	88.2 ± 3.0	p = 0.153
C2	79–91	85.2 ± 3.5	p = 0.029
D2	85–97	90.6 ± 4.8	p = 0.074

DISCUSSION

It is commonly believed that insufficient vascularisation of the oesophageal substitute, and notably — of its peripheral part, is the main factor contributing to the occurrence of anastomotic leaks [4, 9, 8, 13]. That is why attempts have been made to determine the blood flow in the produced substitutes during the operation [10]. It is difficult to perform, as the blood supply of the fundus of the stomach prepared as the transplant is mainly provided by the vessels of the submucous plexus [8, 12]. Individual variations of the afferent and efferent blood vessel network in the stomach and in the oesophagus, blood pressure fluctuations during the prolonged operation, the technique of forming the "transplant" and the method of extending it to the neck, as well

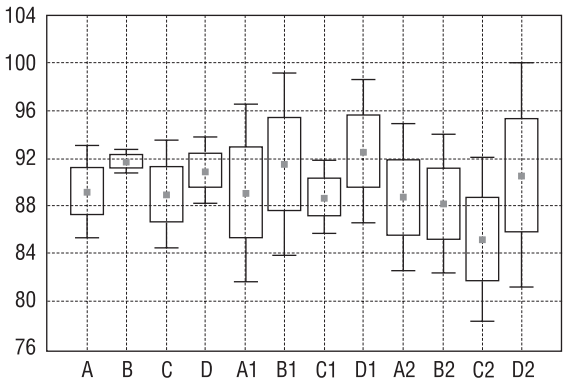

Figure 3. Picture of the blood oxygenation in all examined places of stomach in 45 patients with oesophageal cancer.

as the insufficiency of the organs which leads to systemic disorders, may all affect the healing of the anastomoses [5, 13, 14]. When examining the vascularisation of oesophageal substitutes formed from stomachs using a pulse oximeter, Salo et al. [10] observed an oxygenation in anastomosis, which ranged from 84% to 95%, and did not observe a fistula in any of the cases. They also found that the values of blood oxygenation in the region of the pylorus were slightly higher than in the regions of the anastomoses.

In our study, anastomotic leaks were observed in four patients. Only in one case was it possible to find a correlation between a "poor" picture of the produced transplant, which indicated ischaemia, and the low values of oxygenation recorded in the examined places. In the three other cases of the presence of fistulas, no correlation was found (the values of the oxygenation were similar to those in cases without fistula). The obtained values of blood oxygenation in the specified points (A, B, D, A1, B1, D1, A2, B2, D2) of oesophageal substitutes before and after they were formed did not reveal significant changes and fluctuated considerably. In the examined points of the peripheral regions of oesophageal substitutes — points C1 and C2 — blood oxygenation was lower, compared to the analogous place in the stomach before it was transformed. This fact may be explained by the lowering of the blood flow in the region, caused by the shaping of the stomach (cutting off the blood flow from the left gastric artery and the left gastro-omental artery) and its stretching. Schilling et al. [12] observed a similar phenomenon in the formed gastric substitutes evaluating the blood flow with laser Doppler flowmetry. The method offers a prospect of a more precise evaluation of the blood flow and of an intraoperative assessment of the vitality of gastric or intestinal substitutes for the oesophagus [11, 12]. There were no correlations between pulse oximetry values observed and the presence of anastomosis leak.

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