The Use of Axial Pedicle Platysma Myofascial Flap for Reconstruction of Circumferential Defect in Canine Cervical Esophagus: A Preliminary Study

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Abstract

Background: In various studies, the platysma muscle was used as myofascial flap for intraoral reconstruction and as musculocutaneous flap for esophageal reconstruction. However it was not used as myofascial flap for esophageal reconstruction. In this preliminary study, an early postoperative result of the usage of myofascial flaps for esophageal reconstruction in the dog model is presented.

Methods: Platysma myofascial flaps were used in reconstruction of circumferential defects of cervical esophagus in mongrel dogs. The platysma muscle and the superficial layer of deep cervical fascia were used as a myofascial flap in 13 young adult mongrel dogs. First 3 dogs were used to evaluate the size of esophagus and exploration of platysma. In the remaining 10 dogs, axial pedicle myofascial platysma flaps were harvested. The flaps were raised on the superficial cervical branch of omo cervical artery. The flaps were inverted to form a tube and interposed to 6 cm to 8 cm long defects created in the cervical esophagus.

Results: Barium esophagograms were performed in 3 dogs at 21 days and in 5 dogs at 35 days postoperatively. Minimal narrowing and irregularity observed in the reconstructed segments at 21 days disappeared at 35 days. Migration of esophageal mucosa over the reconstructed segment was found to be irregular on the 21st day, however on the 35th day the whole segment was covered with esophageal mucosa as demonstrated by histological investigations.

Conclusion: Platysma myofascial flap may be considered in reconstruction of cervical esophagus; however more experimental and clinical studies are needed before moving on to its usage in human.

Introduction

Platysma muscle is known as a phylogenetic remnant of panniculus carnosus within the subcutaneous tissue of the anterior neck [1]. This muscle has been used usually as a musculocutaneous flap and rarely as myofascial flap for reconstruction of the head and neck defects. However the platysma was not used as myofascial flap for esophageal reconstruction.

Various surgical techniques have been advocated, such as biosynthetic materials [2-5], gastric transposition [6-8], free jejenum transfers [7,9], musculocutaneous flaps [10-12], local and regional skin flaps [8,13-15], muscular flap [16], free fasciocutaneous flaps for treatment of long gap esophageal defects [17-19]. Recently tube-shaped tissue-engineered substitutes for reconstruction of the circumferential esophagus reconstruction are being used in experimental studies [20-22]. These surgical techniques cause various complications such as leaks and fistulas in anastomose line, narrowing and obstruction in lumen and donor site deformity in clinical and experimental studies [2,3,8,14,17].

Clinical application of the platysma musculocutaneous flaps has yielded good result and few donor site deformities [23-30]. Up till now, it was used as myofascial flap for intraoral reconstruction but not for esophageal reconstruction [27]. The platysma has been used as muscular and musculocutaneous flap to reconstruct cervical esophageal defects [24,28,29].

Myofascial flap elevation is easier than musculocutaneous flap elevation, because there is no need for concern about blood supply to skin layer [27]. Furthermore, the myofascial flap is more flexible than the musculocutaneous flap as epithelial debris and hair accumulation is not a concern and less donor site deformity when compared with musculocutaneous flaps.
The first report about the usage of platysma flap was by Schobinger R in 1959 for cervical esophagus reconstruction [31]. There was no information in the article whether cervical fascia was included in the flap. In this study, we have used axial pedicle platysma myofascial flap to reconstruct circumferential defects of cervical esophagus in the dog model.

**Materials and Methods**

Thirteen young adult mongrel dogs were used in this study. First 3 dogs were used to evaluate the size of esophagus and platysma. Ten dogs with an age ranging from 6 to 10 months and weight from 8 kg to 10 kg were operated. The dogs were operated under xylazine hydrochloride (2%, 2 mg/kg) and ketamine hydrochloride (10%, 15 mg/kg -20 mg/kg) anesthesia and intubation with pediatric endotracheal cuffed tube. More ketamine was used when it was necessary. 500 mg sulbactam-ampicillin was used by intramuscular injection for prophylaxis 1 hr preoperatively. The operative area was shaved and prepared with povidone-iodine solution 6 to 8 cm segment of cervical esophagus; starting 1 cm to 2 cm below the laryngotracheal junction was resected to create an esophageal defect. Platysma myofascial flap based on left superficial branch of the omocervical artery pedicle was raised and transposed to the defect. Antibiotic administration was continued twice a day during the first week, with a total dose of 500 mg per day.

The dogs were housed in separate cages, followed up by the veterinarian under 12 hrs light-dark cycles. Food and water were not given during the first day. They were nourished by 0.9 percent NaCl infusion 1000 cc per day during first the 3 days. They were allowed to drink water after the first day, vitamin enriched milk after 2 days. Infusion of NaCl was stopped on the 4th day and daily food requirements were given in 3 divided feedings of pediatric nutrition liquids by pharyngostomy tube. The tubes were removed if there was no evidence of any fistula on the 8th postoperative day and the dogs were allowed to have liquid diet thereafter.

The dogs were divided into two groups of 5 each as 3 and 5 week observation. Two dogs died at 5th and 14th days. Therefore, the remaining 3 dogs were sacrificed on postoperative 21st day for investigation of early changes and results. Five dogs in the second group were sacrificed on postoperative 35th day for evaluation of midterm structural changes and results. In both groups barium esophagograms were obtained. The reconstructed segment was excised 1 cm to 1.5 cm above and below the anastomoses so as to include native esophagus as well. All specimens were fixed in 10% buffered formalin and processed for light microscopy. Sections of paraffin embedded tissues were cut at 3 μm thickness and routinely stained with hematoxylin and Eosin (H&E).

**Surgical Technique**

After the induction of general anesthesia and endotracheal intubation, the origin and the course of the pedicle on the neck was marked by Doppler ultrasound (Figure 1). A 6 cm to 7 cm long vertical incision starting from the thyroid cartilage in the anterior cervical mid-line was connected with a 5 cm incision coursing parallel to scapular spine (L-shaped, opening laterally). A skin flap with dimensions of 7 cm × 12 cm was raised to access the platysma muscle. The lower border of the platysma flap was 10 cm to 12 cm long running parallel to spinia scapula. The upper border of the flap was designed with a transverse incision 10 cm to 12 cm cranial to the lower incision running parallel to it. Lateral border of the flap was the insertion line of the platysma to the neck muscles and was designed as 9 cm long. The medial border was designed 9 cm long and running parallel to the lateral border.

The flap was raised starting from the lateral border after...
identification of the pedicle (superficial branch of the omocervical artery) at the inferomedial border under (x4) loupe magnification (Figure 2).

The flap was elevated with dimensions of 8 cm × 11 cm (Figure 3). The flap was sutured in two layers (fascia and muscle) so as to form a tube 6 cm to 8 cm in length and with a diameter of 2.5 cm to serve as neoesophagus (Figure 4).

The esophagus was reached after blunt dissection of the strap muscles of the neck in the midline. Cervical esophagus was dissected starting from laryngotracheal junction down to incisura jugularis. A 6 cm to 8 cm long segment starting 1 cm to 2 cm below the laryngotracheal junction was resected circumferentially. The upper and the lower stumps of the esophagus were anchored to the prevertebral fascia with 3/0 absorbable sutures to prevent contraction of the remaining native esophagus. The platysma myofascial flap already tubed was transposed to the esophageal defect and sutured in two layers (muscle inside and fascia outside) by 5/0 and 4/0 nylon sutures (Figure 5).

A full thickness incision was made 1 cm posterior to the left mandibular angle and an 18F Foley catheter was inserted to the stomach to serve as an orogastric tube. A penrose drain was placed under the reconstructed esophageal segment. The strap muscles were approximated by 4/0 absorbable sutures and skin was closed with 4/0 nylon sutures. A light dressing was applied over the wound.

Results

Six animals (60%) had anastomotic leaks, which became evident during the first 3-5 days. Leaks in 2 dogs were minimal and closed spontaneously within ten days. One of the dogs, which had complete anastomotic separation and localized abscess in the esophageal fold died on the 5th postoperative day. Three dogs with anastomotic leaks were explored with the observation of no decrease in the leak on 7th postoperative day. Proximal anastomotic fistulae were observed in two dogs and distal anastomotic fistula in one dog. These were reanastomosed after debridement and pharyngostomy tubes were kept in place for another 7 days in the esophagus. The dog with the distal anastomotic fistula had progressive swallowing difficulties and she was sacrificed 14 days after the initial operation. Severe narrowing on distal anastomosis line was observed by macroscopic evaluation.

Randomly chosen 3 dogs were sacrificed on 21st postoperative day following the performance of barium esophagograms. Radiographic evaluation revealed minimal narrowing and irregularity in the operated segments (Figure 6).

Macroscopic evaluations at autopsy showed that the myofascial flaps were lying in the esophageal fold and anastomoses were intact with no evidence of any constriction, proximal dilatation or fistula in all dogs (Figure 7).

Anastomose lines of operated esophageal segment. Ps: Proximal esophagus; Os: Operated segment; Ds: Distal esophagus.

Luminal surface of operative segment was covered by granulation, which moved over loose and rough adipose tissue. The epithelialization advanced from ends of native esophagus to flap irregularly (Figure 8).

Light microscopic evaluation showed that both anastomoses were intact and healed well. Acute inflammatory reaction was observed and irregular granulation covered the flap surface. The esophageal epithelium advanced from esophageal ends to the flap surface (Figure 9).

Surface of operated and native esophageal segment (x 40, H&E). Natural esophageal mucosa moved from native esophageal end to reconstructed segment (platysma). Arrow, epithelial movement to surface of reconstructed segment.

In the second group, 5 dogs were sacrificed on 35th postoperative day after barium esophagograms were performed. There were not any leaks, fistulae or stricture in any of the dogs by radiographic evaluation. Also, there was no dilatation of the native esophagus and the operated segment (Figure 10).

By macroscopic evaluation at autopsy the interposed myofascial flap was lying in the esophageal fold. There was not any fistula formation. Luminal surface of the operative segment was covered by the natural esophageal epithelium (Figure 11).
Histological examination revealed that acute inflammatory reaction decreased significantly and the reconstructed segments were covered with thin and regular granulation tissue. The natural esophageal epithelium covered the surface of the reconstructed segment completely in all the animals (Figure 12).

**Discussion**

Several techniques, such as biosynthetic materials [2-4], gastric transposition [6-8], free jejunal transfers [7,9], myocutaneous flaps [10-12], local and regional skin flaps [8,13,15], muscular flaps [16], free fasciocutaneous flaps [17-19] were used to reconstruct the esophageal defects. Nowadays, free jejunal transfers and fasciocutaneous flaps are preferred choices owing to their versatility to obtain more functional reconstruction as well as lower morbidity [18]. However, complications like donor area morbidity, fistula formation, dysphagia, regurgitation of secretion are not completely eliminated owing to preservation of secretory and peristaltic structure of jejunum in the transplanted area in free jejunal transfers [7,9,17]. Free jejunal transfer requires laparotomy and subsequent bowel anastomosis. Also, it is a lengthy procedure with increased postoperative morbidity especially in debilitated patients [27].

On the other hand, conspicuous scarring, distortion of body contour (especially breast distortion in female), functional deficit, bulky tissue transfers, difficulties in creation of leak proof anastomoses between skin of flap and mucosa of esophagus, high fistula ratio, stricture in anastomosis line, growing of hair into the lumen and epithelial desquamation still appear as complications in myocutaneous flaps [10,12]. Muscular flaps also, cause functional deficit and contour deformity owing to their bulky structure but contour deformity is less than the myocutaneous flaps. Muscular flaps require skin grafts to reconstruct the luminal surface which cause contraction and shrinkage in the reconstructed esophageal segment [14]. Fistula formation, growth of hair in the lumen and epithelial desquamation are common complications of musculocutaneous, fasciocutaneous and skin flaps [8].

Musculocutaneous flaps have more blood supply than the skin flaps [12]. Free fasciocutaneous flap provides constant blood supply and a longer pedicle and eliminate the need for staged operations [17]. However, hypostenia and conspicuous scarring in the donor area, in addition to high fistula ratio and stricture in the anastomosis are still likely complications [17,19]. Reconstruction with a free fasciocutaneous flap requires micro vascular anastomosis and an available vascular network in the recipient area. Despite the thickness of the flap is reduced, primary closure of the skin in the recipient area can be difficult to perform [18].

The platysma flap has been used frequently in head and neck

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**Figure 8:** Macroscopic view on the 21st day postoperatively; The epithelialization advanced from ends of native esophagus to flap irregularly. Arrows, Anastomose lines of operated esophageal segment. Ps: Proximal esophagus; Os: Operated segment; Ds: Distal esophagus.

**Figure 9:** Microscopic view on the 21st day postoperatively; internal surface of operated and native esophageal segment (x40, H&E). Natural esophageal mucosa moved from native esophageal end to reconstructed segment (platysma). Arrow. Epithelial movement to surface of reconstructed segment.

**Figure 10:** Esophagogram on the 35th day postoperatively, narrowing and irregularity decreased after the end of acute inflammation phase. Arrows, Proximal and distal ends of operated esophageal segment. T: Trachea.

**Figure 11:** Macroscopic view on the 35th day postoperatively; internal surface of operated segment and native esophageal segments. Reconstructed segment was covered by natural esophageal mucosa totally. Arrows, Anastomose lines of operated esophageal segment. Ps: Proximal esophagus; Os: Operated segment; Ds: Distal esophagus.

**Figure 12:** Microscopic view on the 35th day postoperatively; internal surface of operated and native esophageal segment (x40, H&E). Reconstructed segment was covered by natural esophageal mucosa totally.
reconstruction in clinical [32-34] and experimental studies [23-30] owing to its constant and rich blood supply [35,36]. It has been used as myofascial flap for reconstruction of intraoral defects [26], but to the best of our knowledge it has not been used for reconstruction of the esophagus. In this study, we used the platysma myofascial flap for reconstruction of circumferential defects of cervical esophagus in the dogs. Main reason for choosing the myofascial platysma flap was its thin structure which could facilitate leak proof anastomosis with similar fibers to esophageal muscle. Platysma muscle without the fascia was used for reconstruction of the cervical esophagus in dogs by Schobinger in 1959 [31]. The fistula rate in our study was lower than his results probably because he used the muscle flap only without the fascia. It seems that fascia brings strength to the flap integrity. We also observed that the operated segment maintained its dimensions, macroscopic and microscopic structure after 5 weeks. The internal surface of the lumen was covered up by natural esophageal mucosa migrating from the natural esophageal wall in our study. Minimal narrowing and irregularity at the anastomotic line, which was observed at 3 weeks, disappeared after 5 weeks. The high fistula rate and the anastomotic leakage could be related to the absence of submucosal layer in the esophagus. The esophageal muscular layer consists of two layers of skeletal muscles forming apolar screw-like fascicles that run in opposite directions in dogs [37,38]. Skeletal muscle is limited to upper two-third and lower third contains only smooth muscle in human Esophagus [39]. We observed strong tendency to retraction in distal and proximal segments of the remaining esophagus after the excision and the tension was excessive at the anastomotic line. In addition, pharyngostomy tube may have triggered vomiting and retching in the dog which led to excessive tension in the anastomotic line, thus delay of wound healing and a high fistula rate observed in our study. Schobinger also, observed esophageal contraction probably more than ours, as the platysma flap did not include the superficial layer of deep cervical fascia in his study. Wada et al. stated that the surface of the flap was nearly naturally epithelialised and scatrical contraction did not occur where they used platysma muscle with the superficial layer of deep cervical fascia to reconstruct intraoral defects [27]. Fascia under the platysma will maintain its function as a viable and functional lumen even if platysma muscle contracts partially because fascia is more resistant than muscles to contraction. In addition, the fact that is, including the fascia to platysma flap enhance the blood supply of reconstructed esophageal segment. Fascial structures can contract partially (18%) when they are elevated without innervations [40]. For that reason the superficial layer of deep cervical fascia, which covers the muscle provides preservation of integrity in this segment even if the muscle contracts significantly by time. Shinhar et al. stated that they reconstructed partial and circumferential defects in cervical esophagus with “Collagen-coated Vicryl mesh” in dogs and the reconstructed segment healed totally and they did not seen any scar after 3 months. They reported that mature glandular structures and maturation of muscle was observed 6 months postoperatively [4]. We believe that nerve tissue will move ahead from the native esophagus to the operated segment by nerve in growth in time. There are many studies, which report that sensorial innervations makes progress from moderate to high level after the reconstruction of intraoral and pharyngeal defects with the musculocutaneous flaps [41-44].

In this experimental study we reconstructed segmental defects of cervical esophagus by elevation of the platysma myofascial flap based on superficial cervical branch of the omocevical artery [23]. Morbidity and mortality rates we have encountered necessitate more studies to be performed before moving on to human application.

Conclusion

We have found a lower mortality and morbidity rate (10 percent mortality and 60 percent morbidity) in our study when compared to similar studies. We have not observed permanent complications such as stricture and swallowing difficulties, which are usually encountered in clinical studies. We conclude that the platysma myofascial flap could be an alternative in human cervical esophageal circumferential reconstruction with its similar anatomical features to esophagus.

References


