Triceps brachii muscle reconstruction with a latissimus dorsi muscle flap in a dog

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Case Description—A 6-year-old spayed female Border Collie was examined for a severe deformity of the right forelimb. Three months prior to examination, the patient awkwardly fell off the couch and became acutely lame in the right forelimb, progressing to non-weight bearing over the following 72 hours.

Clinical Findings—On physical examination, the dog carried the limb caudally against the thoracic wall, with the shoulder flexed and elbow in extension. The right triceps brachii muscle was atrophied and contracted, resulting in a resistant tension band effect that precluded manipulation of the right elbow joint. The physical changes in the triceps muscle were considered the primary cause of the patient’s loss of limb function.

Treatment and Outcome—Surgical treatment by means of elevation and transposition of the ipsilateral latissimus dorsi muscle was performed. The exposed triceps brachii muscles were transected 3 cm proximal to the tendons of insertion. Via a separate incision, the right latissimus dorsi muscle was elevated and tunneled subcutaneously beneath the interposing skin between the 2 surgical incisions. The muscle was then positioned and sutured to the proximal and distal borders of the divided triceps muscle group. Two weeks later, physical therapy was initiated. After 2 months, the patient regularly walked on the limb most of the time (9/10 steps).

Clinical Relevance—The surgical procedure for elevation and transposition of the latissimus dorsi muscle was relatively simple to perform. Physical therapy was an essential component to achieving the successful functional outcome in this case. This technique may be considered for treatment of similar patients in which the triceps muscle group is severely compromised. (J Am Vet Med Assoc 2015;246:226–230)

A 6-year-old spayed female Border Collie was examined at Angell Animal Medical Center with severe deformity of the right forelimb. The owner witnessed the patient awkwardly fall from the couch, with a height of 18 inches, 3 months prior to initial examination. There was no history of prior trauma. The patient immediately became acutely lame in the right thoracic limb after the fall: this progressed to non–weight bearing over the following 72 hours. The patient was examined at Angell Animal Medical Center with a height of 18 inches, 3 months prior to initial examination. There was no history of prior trauma. The patient immediately became acutely lame in the right thoracic limb after the fall: this progressed to non–weight bearing over the following 72 hours. The dog carried the limb caudally against the thoracic wall, with the shoulder flexed and elbow in extension. The right triceps brachii muscle was atrophied and contracted, resulting in a resistant tension band effect that rigidly fixed the right elbow joint in extreme extension. These physical changes in the triceps muscle were considered the primary cause of the patient’s loss of limb function. Results of a CBC and serum biochemical analyses were within reference limits.

Surgical treatment by means of elevation and transposition of the ipsilateral latissimus dorsi muscle was performed. The objective was to enable the transposed muscle flap to replace the function of the severely injured triceps muscle group, with the eventual goal of functional ambulation on all 4 limbs for this patient. Cefazolin sodium was administered 1 hour prior to surgery, and the patient was premedicated with butorphanol (0.3 mg/kg [0.14 mg/lb], IM), midazolam (0.3 mg/kg, IM), and maropitant citrate (1 mg/kg [0.45 mg/lb], IV), followed by induction of anesthesia with propofol (5.0 mg/kg [2.3 mg/lb], IV). An endotracheal tube was then placed, and anesthesia was maintained with isoflurane in oxygen. A brachial plexus block was performed with 0.5% bupivacaine (0.5 mL/kg [0.23 mL/lb]). Lactated Ringer’s solution was administered at a rate of 5.0 mL/kg/h for the duration of surgery.

The patient was placed in left lateral recumbency, and the surgical site was clipped and prepared for surgery in a routine manner. A lateral skin incision was made from just distal to the mid shaft of the right lat-
eral humerus to the olecranon. The subcutaneous tissue and fascia were incised and separated from the deep brachial fascia. A No. 15 scalpel blade was used to incise the deep brachial fascia over the division between the long and lateral heads of the triceps brachii muscle. The long accessory, lateral, and medial heads of the triceps brachii muscle were individually isolated after blunt dissection. The elbow was manually flexed as the triceps brachii muscles were progressively transected 3 cm proximal to the tendon of insertion. After complete transection of the lateral and long heads, the cubital joint was able to be flexed to approximately 60°. The accessory and medial heads were then divided, improving cubital flexion to approximately 40°, similar to the left elbow. Biopsy samples of the pale, fibrotic triceps brachii muscle were obtained from the proximal myotomy site and submitted for histologic examination.

A right lateral thoracic skin incision was then made over and parallel to the right latissimus dorsi muscle. The latissimus dorsi muscle was elevated with Metzenbaum scissors, cranial to its rib attachments. The dorsal muscle incision, beginning at the head of the 11th rib, was created parallel to the lower border of this muscle mass. During sharp dissection, the lateral intercostal vessels deep to the latissimus muscle were divided with electrocautery. The thoracodorsal artery and vein were identified and preserved.

The latissimus dorsi muscle flap was tunneled subcutaneously beneath the interposing skin between the 2 surgical incisions (Figure 2). The muscle was transposed to bridge the gap created from the transected portions of the triceps brachii muscle. Care was taken not to twist or stretch the thoracodorsal vessels during transposition. The aligned borders of the latissimus dorsi muscle flap were sutured into the proximal and distal borders of the divided triceps muscle group by use of a series of interrupted cruciate 2-0 nylon sutures.

Laxity along the length of the transposed latissimus dorsi muscle was then reduced by partial suture apposition of the dorsal incised border to its original opposing incised muscle border with 3 interrupted 2-0 nylon cruciate sutures. With the elbow held in extension, each tension suture was tied. The transposed latissimus dorsi flap progressively shortened, increasing tension along the length of the muscle. With application of the third suture, mild restrictive tension was palpable proximal to the olecranon. Slight resistance was noted when the elbow was flexed. The transposed latissimus dorsi muscle was moderately taut along its axis so that subsequent muscle contraction would better replicate the function of the replaced triceps muscle group.

A 10-mm flat drain was inserted through a 1-cm stab incision caudodorsal to the lateral thoracic incision; a 100-ml vacuum reservoir was placed on the external end of the drain. The drain was secured to the skin by use of 2-0
The skin margins were apposed with skin staples. The patient recovered uneventfully from surgery and received cefazolin sodium (20 mg/kg [9.1 mg/lb], PO, q 8 h) and hydromorphone (0.05 mg/kg [0.02 mg/kg], PO, q 6 h) over the next 24 hours of hospitalization. The patient was discharged the following day with tramadol (2 mg/kg [0.9 mg/lb], PO, q 12 h) for 3 days and carprofen (2.2 mg/kg [1 mg/lb], PO, q 12 h) for 10 days. The patient returned for drain removal 4 days later. Skin staples were removed 2 weeks after surgery. Postoperative instructions to the owner included manual placement of the right forelimb in a standing position daily with the owner gently flexing and extending the elbow, shoulder, and carpal joints over the first 2 weeks. After this time, the dog was referred to a certified canine rehabilitation practitioner (PT) for physical therapy.

The patient received physical therapy twice weekly for the first 4 weeks, followed by once weekly for the next 8 weeks. During each session, low-intensity laser therapy was applied to the right triceps area and shoulder and scapular region with a laser; at 6 J/cm² for the first 3 treatments, followed by 7 J/cm² for the remaining treatments. A hot pack was placed on the patient's right shoulder and triceps area for 10 minutes, followed by massage and gentle manipulation of the limb, through its range of motion in each session of 10 to 15 repetitions. A small carpal brace was applied to the dog's left forelimb for additional support during physical therapy sessions. The dog was then balanced over a physio roll with the limbs placed on opposing sides of this ball. The patient's weight was then shifted forward-to-back and side-to-side (10 repetitions initially, progressing to 30 repetitions during subsequent visits). The owners continued the patient's physio ball therapy at home daily, along with hot packs to the shoulder and elbow region of the right forelimb between visits. The owners were also instructed to have the patient sit and then stand with the left and right front paw planted on the floor for a total of 10 to 15 repetitions.

After completing this portion of the prescribed physical therapy, the final component of the patient's physical therapy consisted of underwater treadmill therapy, which commenced 2 weeks after surgery. Water depth was initially at shoulder height, with a treadmill speed of 55 to 65 steps/min. The patient was walked for 5 minutes, followed by 2 minutes of rest before resuming a second 5-minute walking session during the first week. Because placement of the right forelimb was inconsistent during the first 3 treatments, the physical therapist (PT) lifted the patient's hind limbs (in a wheelbarrow fashion) during subsequent treadmill sessions to compel the patient to place the right forelimb. The patient was strongly motivated to walk when offered pieces of chicken as well as verbal encouragement by the owners when bearing weight on the affected extremity. Over the next 2 weeks, the water level was raised and lowered periodically to encourage the patient to bear weight on the right forelimb. By the end of the fourth week of physical therapy, the patient was able to walk for 11 minutes and resume a second 11-minute walking session after 2 minutes of rest. At this time, the water height was lowered to the level of the mid humerus, with the speed varying from 65 to 100 steps/min. With the therapist periodically assisting the patient inside the treadmill tank, the family members, located at the front area of the treadmill, continued to encourage the patient to walk. (Online supplement available at avmajournals.avma.org/toc/javma/246/2).

Physical therapy sessions were then performed every other week. After 5 weeks of therapy, the patient would ambulate on the right front limb 60% of the time (weight bearing for 6/10 steps) when leash walked with family members. After 2 months, the patient walked on the right forelimb 90% of the time (weight bearing for 9/10 steps), when the patient was not distracted or anxious by the presence of other dogs. When non-weight bearing, the patient would then hold the right forelimb with the shoulder and elbow flexed and the carpus extended. Therapy sessions continued for a total of 7 months, at which time the owners were comfortable with home therapy, which consisted of walking the dog 20 minutes per day supplemented with stretching and range of motion exercises for the affected limb. At the time of writing, physical therapy was no longer required. The patient continued to use the leg most of the time when walking; the owner provided treats when the dog occasionally hesitated placing the leg. When the dog ran, it had a tendency to carry the leg.

Histopathologic findings in the skeletal muscle samples obtained at surgery included regional fibrosis, focal acute myofiber degeneration, rare myofiber regeneration, and minimal fatty infiltration of skeletal muscle fascicles. Features of acute damage were minimal; therefore, a focal monophasic (rather than polyphasic) reaction was favored. The predominant microscopic lesion was one of chronic or previous myofiber damage resulting in replacement fibrosis.

Discussion

The latissimus dorsi muscle is a flat, almost triangular-shaped muscle overlying the dorsal half of the lateral thoracic wall. Its location caudal to the shoulder and brachium allows the surgeon to elevate this broad muscle on the basis of the dominant thoracodorsal artery and vein as well as its innervation (n. thoracodorsalis and nn. pectoralis caudales.) Perforating intercostal vessels also supplement the length of this muscle to a lesser degree: their ligation during latissimus dorsi muscle elevation from the thoracic wall does not affect its function. The most caudal border of the latissimus dorsi muscle attaches to the fascia of the last 2 or 3 ribs.1 The action of the latissimus dorsi muscle includes drawing the trunk forward and possibly laterally to a variable degree; contraction of this muscle depresses the vertebral column, supports the limb, draws the limb against the trunk, and draws the free limb caudally during flexion of the shoulder joint.1 Clinically, loss of this muscle secondary to trauma, resection, or transposition does not adversely affect forelimb function in the dog and cat. As a result, this broad-based, superficial muscle flap is ideally suited for reconstructive surgery within its general arc of rotation.3–4

The action of the triceps brachii muscle is to extend the elbow and fix it in position during weight bearing. Loss of this action would result in the inability of a dog...
to bear weight on the affected extremity. The triceps muscle consists of 4 heads (the long, lateral, medial, and accessory heads), with a long tendon attaching to the olecranon. This muscle group is innervated by the radial nerve and is supplied by branches of the deep brachial artery. The deep brachial artery is a branch of the brachial artery, as a single or double branch, in the proximal third of the forearm. This small vessel anastomoses with the caudal circumflex humeral artery proximally and the collateral ulnar artery distally. The radial nerve enters the triceps muscle cranial to the deep brachial artery. In the patient described in the present report, the bizarre history and lack of specific histopathologic change in the biopsy specimens obtained at surgery precluded determination of the etiology, although these may have included ischemia, trauma, or mechanical injury.

Effective surgical transfer of the latissimus dorsi muscle in dogs as a singular flap, bipedicle flap, or compound or myocutaneous flap was first reported in the veterinary literature by the first author (MMP). Single pedicle and bipedicle muscle flaps are considered the preferred methods to reconstruct the thorax after major tumor resection involving several ribs.

The first author has previously used a portion of the latissimus dorsi muscle to bridge a severed triceps muscle defect proximal to its tendinous attachment to the olecranon in a Chihuahua cross; muscle loss was secondary to bite wound trauma. In that small patient, the transposed muscle flap was sutured to the viable severed ends of the triceps muscle, spanning the 3- to 4-cm muscle gap. As a result, contraction of the viable triceps muscle in that Chihuahua was transmitted through the interposing latissimus dorsi muscle segment to its tendinous attachment to the olecranon. In essence, the small latissimus dorsi muscle flap provided a viable tissue bridge in the triceps muscle gap; the force of muscle contraction of the triceps muscle mass was transferred via the flap to the viable tendinous attachment to the olecranon.

There are numerous articles regarding the use of the latissimus dorsi muscle in human reconstructive surgery, both as rotational flaps or as free flaps employing microvascular anastomosis. Representative clinical application of similar flaps in human patients includes use for replacement of the biceps muscle, breast reconstruction, and cardioplastic. As a free flap, the latissimus dorsi muscle has been used to replace the quadriceps muscle group and for closure of extensive lower extremity defects in human patients secondary to trauma and tumor resection and for treatment of complications (soft tissue injury) associated with radiation therapy.

In dog of the present report, the dramatic atrophy and contracture of the right triceps muscle required muscle replacement. Division of the right triceps muscle reestablished full range of motion to the elbow, but at the expense of losing limb function. The latissimus dorsi muscle, on the basis of its location and ease of elevation and transfer, was considered the most practical option to attempt restoration of function of this essential triceps unit. The triceps muscle was transected 3 cm proximal to the tendinous attachment to the olecranon, thereby providing a sufficiently long surface area for suture attachment of the latissimus dorsi muscle. The elevated latissimus dorsi muscle was then positioned between the severed borders of the triceps muscle and sutured into position. The craniodorsal edge of the latissimus dorsi muscle was partially reapposed to the original incised margin to increase tension along the length of the muscle while the elbow was held in extension. Placement of interrupted cruciate sutures allowed us to create the appropriate tension to help ensure contraction of the latissimus dorsi would extend the elbow, yet maintain the general range of motion gained after division of the triceps muscle, based on intraoperative manipulation of the elbow.

Once healing was considered sufficient 2 weeks after transplantation, physical therapy was essential to allow the dog to regain function of the affected right forelimb. Repetitive therapy improved muscle mass and tone to the limb muscles and improved range of motion. Importantly, this patient had to be trained to contract the latissimus dorsi muscle to be able to extend and fix the elbow in the process of weight bearing. This is an easier process in human patients, with the cognitive ability to contract the latissimus dorsi muscle, for example, when used as a substitute for the biceps muscle in the rehabilitation process. On the basis of the positive results in this case, this technique could be considered for other cases in which the triceps muscle group is severely compromised.

References


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**From this month’s *AJVR***

Comparison among the euglycemic-hyperinsulinemic clamp, insulin-modified frequently sampled intravenous glucose tolerance test, and oral glucose tolerance test for assessment of insulin sensitivity in healthy Standardbreds

Shannon E. Pratt-Phillips et al

**Objective**—To compare estimates of insulin sensitivity in horses obtained from minimal model analysis (MMA) of a frequently sampled IV glucose tolerance test (FSIGTT) with estimates from the euglycemic-hyperinsulinemic clamp (EHC) and to evaluate the validity of surrogate estimates of insulin sensitivity derived from an oral glucose tolerance test (OGTT).

**Animals**—18 mature Standardbreds (mean ± SD body weight, 428.9 ± 35.9 kg; mean ± SD body condition score, 4.4 ± 1.0 [on a scale of 1 to 9]).

**Procedures**—All horses underwent at least 2 of the 3 procedures (EHC [n = 15], insulin-modified FSIGTT [18], and OGTT [18]) within a 10-day time frame to evaluate insulin sensitivity.

**Results**—Insulin sensitivity variables derived from the EHC and FSIGTT were strongly correlated (r = 0.88). When standardized to the same units of measure, these measures were still strongly correlated (r = 0.86) but were not equivalent. Area under the curve, peak insulin concentration, insulin concentration at 120 minutes, and 2 calculated indices from glucose and insulin data from the OGTT were significantly correlated with the EHC- and FSIGTT-derived estimates of insulin sensitivity.

**Conclusions and Clinical Relevance**—In healthy Standardbreds with moderate body condition score, insulin sensitivities from the EHC and FSIGTT were strongly correlated but not equivalent. Estimates derived from an OGTT also may be useful to estimate insulin sensitivity. (*Am J Vet Res* 2015;76:84–91)