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Neuroanatomy of the wings of indigenous pigeon of Bangladesh

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ABSTRACT

The injury to the wings is the most common clinical problem of the flying birds. Recently we reported neuroanatomy of the wing of mature indigenous duck. Based on these findings we planned to investigate the neuroanatomy of the wing of the mature indigenous pigeon. To the best of my knowledge, there is limited study on neuroanatomy of the wing of the indigenous pigeon. A total of three mature indigenous pigeons were used to investigate the neuroanatomy of wings in this study. The pigeons were humanly killed and dissection was done after complete drainage of blood. It was revealed that the branches originating from the brachial plexus were innervated in the wing of the pigeon. The brachial plexus was formed by the anastomosis of the ventral branches of the last two cervical spinal nerves (C13-C14) and the ventral branches of the first thoracic spinal nerve (T1) just beneath the shoulder joint. The contribution of the nerve fiber originating from the ventral branches of the 12th cervical (C12) spinal nerve and the ventral branches of the 2nd thoracic (T2) spinal nerve were minimum in the formation of brachial plexus in the pigeon. The brachialis superior and brachialis inferior nerves originated from the trunk of brachial plexus were innervated in the musculature of the wings of the pigeon. These results may serve as a basis for the further investigation of the physiological and clinical issues of wings of the indigenous pigeon including all flying birds.

Introduction

Avian species have been used for numerous reasons. At present, birds are used as companion animals, model animals for biological and biomedical research and as sources of high-quality protein (McLelland, 1990). Poultry rearing is an integral part of the rural farming communities in Bangladesh (Amber and Mia, 2002; FAO, 1991). It is recommended that use of animals instead of human as experimental models in biomedical research in order to validate and examine the different physiological and pathological processes. Because there are no in vitro models able to completely reproduce the complexity of the physiology of the human body (Fagundes and Taha, 2004).All animal's body is organized with the different system having a specific function for the maintenance of the normal physiology. The nervous system is the master system of the body and it controls and coordinates all other systems. The central and peripheral nervous system maintain their activities. The injury to the peripheral nervous system is amajor clinical problem in humans and animals. In flying birds, injury to the wing is the most common clinical problem. It may cause the death of birds because of improper treatment due to lacking anatomical knowledge especially branching and innervation of major nerves in the wing of a bird. To treat the injury to the wing, anatomicalknowledge of neuronal pathways and their landmarks has been used for many local and regional anesthetic techniques in mammals (Futema et al., 2002). The brachial plexus nerve block is an important technique to anesthetize the arm of humans (Urban and Urquhart, 1994) and dogs (Futema et al., 2002). Similarly, the wing of birds is innervated with the branches of brachial plexus which is formed by the union of the ventral rami of specific spinal nerves originating from the cervical and thoracic segment of the spinal cords. The formation and branches of brachial plexus vary from species to species even individual to individual. The anatomy of the brachial plexus has been examined in different vertebrates to know the comparative anatomy of the human brachial plexus (Fioretto et al., 2003). The brachial plexus usually originates from the last part of the cervical region and its branches innervate into the axillary region (Fazan et al., 2003).In birds, the brachial plexus innervates the musculature of the wing and the trunk as well as the skin and blood vessels of this region of the body (Nickel et al., 1977). The anatomy of avian brachial plexus has been studied in chicken (Baumel, 1975), cockatiels (Murphy and Shivaprasad, 2008), red-tailed hawks (Shell et al., 1993), great horned owls (Moore et al., 1989) merlin (Cevik-Demirkan, 2014), blue-and-yellow macaws (Achoa Filho et al., 2014) and blue-fronted parrot (Silva et al., 2015). We recently reported the formation and innervation of the brachial plexus of indigenous ducks (Alam et al., 2017). To the best of our knowledge, however, the

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formation and branching of brachial plexus and their innervation have not been sufficiently investigated in indigenous pigeons. In order to investigate the macroanatomy of the brachial plexus of indigenous pigeon, we examined the formation and branching of the brachial plexus, and the innervation of major branches in the wing of indigenous pigeon.

MATERIALS AND METHODS

A total of three mature female indigenous pigeons were used in this study.The pigeons were purchased from the local market near the Faculty of Animal Science and Veterinary Medicine, Patuakhali Science and Technology University, Babugonj, Barishal. All of the Pigeons were apparently healthy and devoid of any external abnormalities (Figure 1A). The live body weights of pigeons varied from 300gm to 400gm. The pigeons were anesthetized with ketamine hydrochloride and xylazine hydrochloride (Renata) @ 60 and 6mg/kg body weight, respectively. All the pigeons were bled to death by giving an incision on the right common carotid artery (Figure 1B). The dissection was done carefully with the simple dissecting instrument. To document the spinal nerves forming the brachial plexus, skin and muscles were dissected, and adipose tissues and mucous substances were removed carefully. The specimens were studied bilaterally. The brachial plexus and the nerve branches emerging from it were carefully dissected and photographed with a digital camera. The terminology used in this study is compatible with that of the Nomina Anatomica Avium (Baumel et al., 1993).

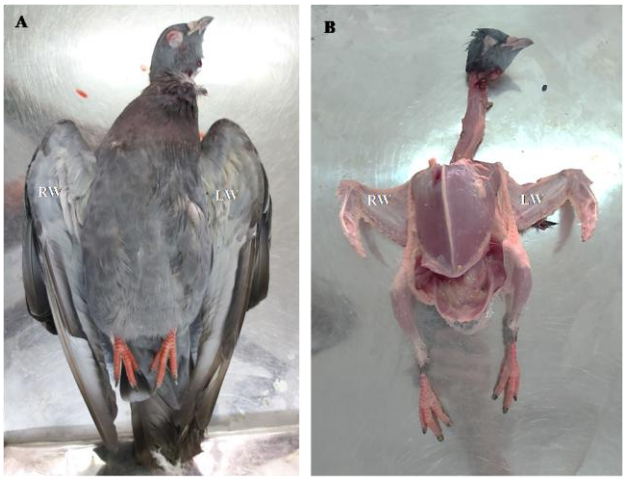

Figure 1: Ventral view of the wings of indigenous pigeons. A. Ventral view of the wing of the whole carcass of the indigenous pigeon. B. Ventral view of wings of the whole carcass after skinning of indigenous pigeon. RW, right-wing; LW, left-wing.

RESULTS

Formation of brachial plexus

This present study provided valuable information regarding the origin of roots from spinal nerves and the formation of brachial plexus in the indigenous pigeon. In pigeons, the brachial plexus was formed by the anastomosis of the ventral branches mainly from the last two (C13-C14) cervical spinal nerves and ventral branches from the first thoracic (T1) spinal nerve (Figure 2A). The ventral branches of the major two (C13-C14) cervical spinal nervesand the first (T1) thoracic spinal nerve contributing to the formation of brachial plexus were almost similar in length and diameter (Figure 2A & 2B). Few small thin nerve fibers originating from theventral branch of the 12th cervical spinal nerve (C12) were united with the ventral branches of thirteenth (C13) spinal nerve. Similarly, few small thin fibers originating from the second (T2) thoracic spinal nerve united with the ventral branches of the first (T1) thoracic spinal nerve which was one of the major contributing thoracic spinal nerves for the formation of brachial plexus in indigenous pigeons.

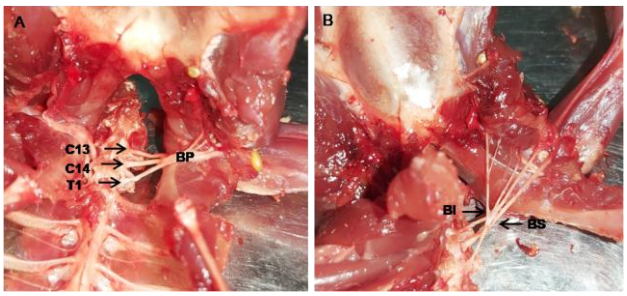

Figure 2: Formation and major branches of brachial plexus in the indigenous pigeon. A. The roots of spinal nerves involved in the formation of brachial plexus. B. The major branches of brachial plexus innervated in the wings and breast region. Cervical thirteen and fourteen (C13, C14), Thoracic1 (T1); Brachial plexus, BP; Brachialis inferior, BI; Brachialis superior, BS.

Branches of brachial plexus withinnervation

The two major branches that originated from the brachial plexus were brachialis superior and brachialis inferior (Figure 2B). The brachialis superior innervates to the muscles at the dorsal aspect of the wing. It runs towards the humerus as

radial nerve innervating the m. triceps brachii, m. extensor carpi ulnaris, m. extensor carpi radialis and m. extensor carpi digitorum communis via its process (Figure 3). The radial nerve was divided into small superficial and deep branches at the elbow joint. The superficial branch innervates into the m. extensor digitorum communis while deep branches were innervated into the m. adductor, m. interosseous dorsalis and m. ulnometacarpalis dorsalis and terminated at m. digitalis.On the other hand, the brachialis inferior nerve was divided into two branches as medianoulnaris nerve and pectoralis nerve (Figure 3).

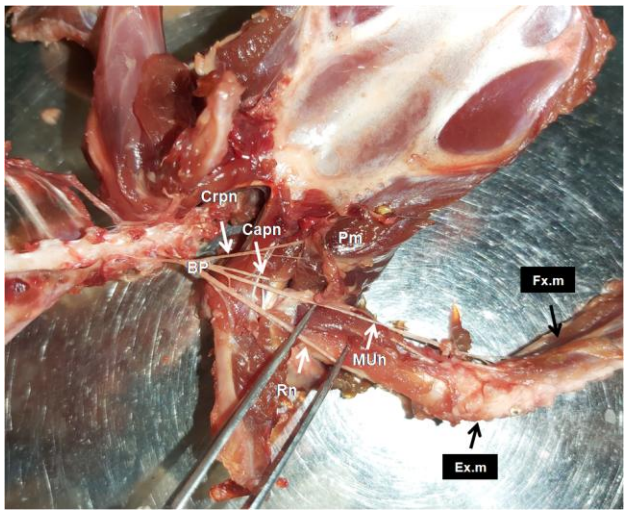

Figure 3: Major branches of brachial plexus with innervation in musculature of wing in indigenous pigeon. BP, Brachial plexus; Crpn, Cranial pectoral nerve; Capn, Caudal pectoral nerve; Pm, Pectoralis muscle; Rn, Radial nerve; MUn, Medianoulnar nerve; Fx.m: Flexor group of muscles; Ex.m, Extensor group of muscles

The medianoulnaris nerve was strong and run along the medial surface of humerus towards the ulna innervating in the m. biceps brachii and the m. coraco brachialis of the wing. This medianoulnaris nerve was also divided into small branches at the elbow joint. These small branches were ulnaris nerve and medianus nerve. The ulnaris nerve innervated into m. flexor carpi ulnaris and m. flexor digitorum superficialis while the medianus nerve innervated the m. flexor carpi radialis, m. flexor digitorum superficialis and m. flexor digitorum profundus of the wing (Figure 3). By contrast, the pectoralis nerve was segregated into two branches as cranial and caudal branch and both branches were innervated in the m. pectoralis of cranial and caudal aspect of the pectoral region respectively (Figure 2A & 2B, Figure 3).

DISCUSSION

The brachial plexus of avian species has been the subject of several clinical, surgical, and experimental issues. The components of the brachial plexus are frequently traumatized during anesthetics procedures and handling of birds especially pigeons during laboratory experiments and marketing without proper care and cautiousness. We recently reported the formation and innervation of brachial and lumbosacral plexus of indigenous ducks (Alam et al., 2017; Hussain et al., 2018). To the best of our knowledge, however, the formation and innervation of brachial plexus have not been sufficiently characterized in indigenous pigeons. In order to characterize details of the brachial plexus of pigeons, therefore, we examined the formation, major branches and their innervation in the different muscles of the wing of indigenous pigeons. In this present study, we found that the brachial plexus was formed by anastomosis of the ventral branches of the last two cervical (C13-C14) spinal nerves and ventral branches of the first (T1) thoracic spinal nerve. The contribution of the small fibers from the ventral branches from the twelfth (C12) cervical spinal nerves and second (T2) thoracic spinal nerve were also identified. Fibers from the twelfth (C12) cervical and second thoracic spinal nerve were not directly involved in plexus formation. Instead of direct plexus formation, they were united with the roots of ventral branches of the thirteenth cervical (C13) and the roots of ventral branches of the first (T1) thoracic spinal nerves. The previous report on brachial plexus in the pigeon was slightly different in the formation of brachial plexus due to the variation in the number of cervical vertebra (C1-C16) and their corresponding spinal nerves (Franceschi et al., 2009). In our previous studies on the indigenous duck, we showed brachial plexus was formed similarly by the union of the ventral branches of the last two cervical (C14-C15) and first three thoracic (T1-T3) spinal nerves (Alam et al., 2017). The root from the cervical 14 (C14) was very small in diameter and was united with the root of the last cervical (C15). Similarly, few tiny fibers originated from the roots of the second thoracic (T2) spinal nerve and merged with the root of the first thoracic (T1) spinal nerve (Alam et al., 2017). In our study, the brachial plexus was formed in the pigeon by the ventral rami of the cervical spinal nerves (C13-C14) and thoracic spinal nerve (T1) which is

different from the other avian species. In chickens, brachial plexus was reported to originate from the last three cervical (C13-15) and first thoracic (T1) (Baumel, 1975). In the ostrich, the brachial plexus originates from the ventral branches of the last cervical and first thoracic spinal nerves (Pospieszny et al., 2009). The brachial plexus of the English sparrow was formed by the three cervical (C11, C12, and C13) spinal nerves (Swinebroad, 1954). In the blue-and-yellow macaws, nerves originate to form brachial plexus from the intervertebral spaces between the tenth cervical vertebra and the second thoracic vertebra (AchoaFilhoet al., 2014). In the blue-fronted parrot, the brachial plexus was formed by the ventral branches of the C9 to C11 and T1 to T2 spinal nerves (Silva et al., 2015). In the brachial plexus of merlins, two trunks were reported as the accessory brachial plexus and the brachial plexus. Accessory brachial plexus consisted of ventral rami of C10 and C11 spinal nerves. The brachial plexus was composed of a rather complex network involving the ventral rami of C11-13, T1, and T2 spinal nerves (Cevik-Demirkan, 2014). In indigenous pigeons, the roots coming from the last two cervical and first thoracic spinal nerves were almost similar in diameter and strength. In our previous study on the indigenous duck, the root coming from the first thoracic was the largest in diameter, whereas, in the chicken, the last cervical nerve was the largest nerve in the brachial plexus (Baumel, 1975). In this study, the brachialis superior run towards the radius through the surface of the humerus arising small branches innervating in the extensor group of the muscle of the wing in indigenous pigeon. In ducks, the pectoral trunk and medianoulnar nerve originated from ventral cord while the dorsal cord gives axillary nerve continued as a radial nerve into the wing (Alam et al. 2017). The brachialis superior run towards the humerus as radial nerve innervating the m. triceps brachii, m. extensor carpi ulnaris, m. extensor carpi radialis and m. extensor carpi digitorum communis via its process. The branches of the radial nerve innervate into the m. extensor digitorum communis, m. adductor, m. interosseous dorsalis and m. ulnometacarpalis dorsalis and terminated at m. digitalis. The branches originating from the brachialis inferior were medianoulnaris and pectoral nerve. The ulnaris nerve innervated into m. flexor carpi ulnaris and m. flexor digitorum superficialis while the medianus nerve innervated into m. flexor carpi radialis, flexor digitorum superficialis, and flexor digitorum profundus muscle of the wing. By contrast, the pectoralis nerve was segregated into two branches as the cranial branch and caudal branch, and both were innervated in the pectoralis muscles. Our findings were almost similar to the branches and innervation of brachial plexus found in common buzzard (Akbulut et al., 2017).

CONCLUSION

The roots originated from the ventral branches of the last two cervical and first thoracic spinal nerves and were united to form the brachial plexus in the indigenous pigeon. The ventral branches of C13-C14 and T1 were the major contributor to the formation of the brachial plexus. The brachial plexus of the indigenous pigeon was made up of several branches that were distributed in the intrinsic and extrinsic muscles of the wing. The results obtained in this study may contribute to applied research especially neuroanatomy of the wing of the pigeon. This also provides information for the comparative anatomy of other avian species. In a nutshell, the data generated from here can provide knowledge of anatomical landmarks for the location of the brachial plexus and can help to determine accurate and reliable techniques of catheter placement for local or regional anesthesia in the wing of indigenous pigeons.

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