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Neuroanatomy of lumbosacral and pudendal plexus in pigeon of Bangladesh

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ABSTRACT

The present study aims to reveal the neuroanatomy of the lumbosacral and pudendal plexus in pigeons of Bangladesh. Six adult male domesticated pigeons were used in this study. The body cavities of the pigeons were opened after the administration of the anesthetics. The nerve roots of the plexus were dissected separately and photographed. We found that the lumbosacral plexus consisted of the lumbar plexus and the sacral plexus. The lumbar plexus was formed by the union of the ventral branches of the first, second, and third lumbar (L1-L3) spinal nerves. The lumbar plexus was branched into cutaneous femoris nerve, coxalis cranialis nerve, femoralis nerve, saphenous nerve, and obturatorius nerve. The sacral plexus was formed by the union of the ventral branches of the fourth lumbar and first, second, third, and fourth sacro-coccygeal spinal nerves. The sacral plexus gives off a large sciatic nerve and innervated as tibial and fibular nerve into musculature of the hind limb of the pigeon. The pudendal plexus was organized from the fourth, fifth, sixth and seventh sacro-coccygeal spinal nerves and were innervated into the tail region of the domesticated pigeons. This study was the first investigation of lumbosacral and pudendal plexus in domesticated pigeons and the results may serve as a basis for further investigation in other species.

Introduction

The poultry sub-sector is an imperative avenue in fostering agricultural growth and reducing the malnutrition of the people in Bangladesh. The pigeon (*Columba livia*) is an important poultry species having the family columbidae and domesticated from the rock pigeon (Gilbert & Shapiro, 2014). The pigeons are used as an alternative source of animal protein, recreation, and commercial purposes. Moreover, pigeons are also used as an experimental model to study the parasite-host relationship and pathogenesis of diseases (Mineo et al., 2009). The bodies of animals including birds are organized with diverse systems having a specific function for the maintenance of their physiology. The nervous system is the master system of any living organism. It controls and coordinates all other systems of the body. The central and peripheral nervous system keep up their activities. Injury to the peripheral nervous system could be the major clinical issues in humans and animals. Injury to the wings and legs is the most common clinical problem in pigeons. These may cause the death of pigeon having improper surgical approach without appropriate anatomical knowledge of wings and legs. The anatomical knowledge of neuronal pathways and their landmarks has been used for many local and regional anesthetic techniques to treat the injury of various regions in animals and birds including pigeons (Mitragotri et al., 2017). The lumbar, sacral and pudendal plexuses are responsible for the innervation of the pelvic

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region, hind limbs, and tail. These three plexuses give off several branches to innervate into the musculatures of their respective regions (Nickel et al., 1977; Dursun, 2007). The blocking of the nerves innervated into the musculature of legs is an important technique to anesthetize the humans and animals (Diwan & Amudha, 2021). The branches from the pudendal plexus are innervated into the skin, organs, and muscles of the perineum and external genitalia. The pudendal plexus migrates through the pudendal canal giving three branches towards the pubic symphysis. There have been many neuroanatomical studies on the lumbosacral plexus in many poultry species such as chicken, goose, turkey, quail, pheasant, and ostrich (Serbest et al., 1993; Serbest, 2000; Can & Ozdemir, 2011; Istanbullugil et al., 2013; El-Mahdy et al., 2010). Recently, we reported the neuroanatomy of the wings of indigenous pigeons (Alam & Hasan, 2022). Based on these findings, we aimed to study on the neuroanatomy of the lumbosacral and pudendal plexus of the indigenous pigeons of Bangladesh. However, to the best of my knowledge, there is no detailed information on the neuroanatomy of the lumbosacral and pudendal plexus of the indigenous pigeons. Therefore, we planned to explore the anatomy of the lumbosacral and pudendal plexus in pigeon of Bangladesh.

Materials and Methods

This study was carried out using six adult (age > 1.5 years) male pigeons of Bangladesh. The pigeons were purchased from the local market of Babugonj upazila of Barishal district. The pigeons were healthy and devoid of any external abnormalities. The body weights of the pigeons varied from 300 grams to 400 grams. The pigeons were anesthetized with ketamine hydrochloride (60 mg/kg body weight) and xylazine hydrochloride (6mg/kg body weight) respectively. All the pigeons were bled to death by giving incision on the carotid artery (Fig.1). The dissection was done carefully with the simple dissecting instrument. An incision was made from the cloaca to the procesesus xiphodeus in all pigeons. The cross- section was expanded around the sternum. The muscles were dissected and body cavities were opened. Internal organs of the body cavity were removed without damaging nerve plexuses. The lumbosacral and pudendal plexus were studied bilaterally. The origin and the branches of the lumbosacral and pudendal plexus were carefully dissected and photographed with a digital camera (Samsung Galaxy M40). The terminology used in the manuscript is compatible with that of the Nomina Anatomica Avium and published scientific reports (Baumel et al., 1993; Huber, 1936; Balkaya & Ozudogru, 2016). Animal experimentation protocols were approved by the Animal Research Committee of Patuakhali Science and Technology University.

Results

Formation and branches of lumbar plexus with innervation

In domesticated pigeons, the lumbar plexus was combined with the ventral branches of the first three lumbar (L1-L3) spinal nerves. The diameter of the root of the second lumbar spinal nerves was the highest and involved in the formation of the lumbar plexus (Fig. 3).

Figure 1. Ventral view of the whole carcass of the domesticated pigeon showing wing and pelvic limb. RW, Right Wing; LW, Left Wing; RPL, Right Pelvic Limb, LPL, Left Pelvic Limb.

We found that the lumbar plexus was branched clearly into a cranial large nerve to innervate into hip and thigh region whereas caudal relatively small nerve innervated into thigh region. The cranial large nerve was branched into distinct four branches namely cutaneous femoris nerve, coxalis cranialis nerve, femoralis nerve, and saphenous nerve. The caudal small nerve was continued as the obturatorius nerve (Fig.4). The lumbar plexus gives off the branches and innervated into the musculature and its associated tissue of the thigh region.

Formation and branches of sacral plexus with innervation

In domesticated pigeons, the sacral plexus was formed with the ventral branches of the fourth lumbar and first four sacro-coccygeal spinal nerves. The contribution of roots of the fourth lumbar and first two sacro-coccygeal spinal nerve were the highest in the organization of the sacral plexus. The small nerve fibers from the third lumbar and fourth sacro-coccygeal spinal nerve united with the root of the fourth lumbar and third

sacro-coccygeal spinal nerve respectively for the formation of sacral plexus (Fig. 5).

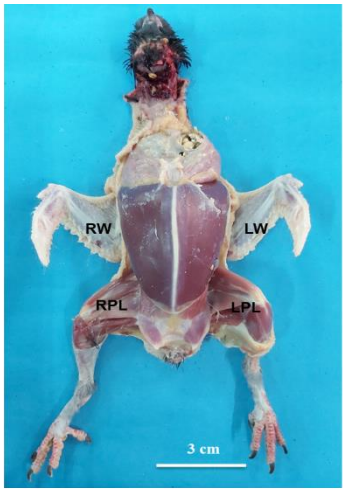

Figure 2. Ventral view of the whole carcass of domesticated pigeon after skinning. RW, Right Wing; LW, Left Wing; RPL, Right Pelvic Limb; LPL, Left Pelvic Limb;.

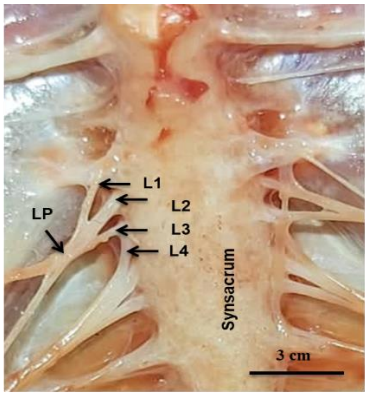

Figure 3. Formation of lumbar plexus in pigeon showing ventral branches of 1st, 2nd and 3rd lumbar spinal nerves. The roots were designated as L1, 1st lumbar spinal nerve; L2, 2nd lumbar spinal nerve; L3, 3rd lumbar spinal nerve; L4, 4th lumbar spinal nerve; LP, lumbar plexus.

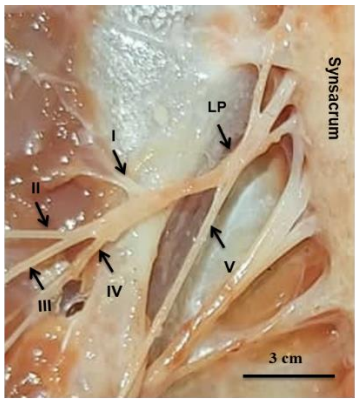

Figure 4. Distinct branches of lumbar plexus in domesticated pigeon innervated into musculature. The branches were designated as I, cutaneus femoris nerve.; II, coxalis cranialis nerve.; III, femoralis nerve; IV, saphenus nerve; V, obturatorius nerve; LP, lumbar plexus.

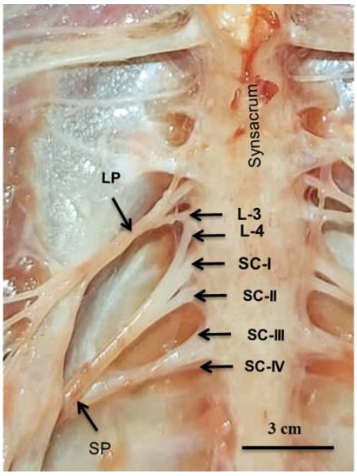

Figure 5. Formation of sacral plexus in pigeon showing ventral branches of lumbar and sacro-coccygeal spinal nerve. The roots were designated as L3, 3rd lumbar nerve; L4, 4th lumbar nerve; SC-I, 1st sacro-coccygeal spinal nerve; SC-II, 2nd sacro-coccygeal spinal nerve; SC-III, 3rd sacro-coccygeal spinal nerve; SC-IV, 4th sacro-coccygeal spinal nerve; and SC-V, 5th sacro-coccygeal nerve.

The sacral plexus gives off single large, a compact cylindrical bundle of nerve medial to acetabular foramen which was termed as sciatic nerve and innervated with few small branches into the musculature of the hind limb of the pigeon. The sciatic nerve was extended along the lateral face of the thigh to the knee and divides into tibial and fibular nerves (Fig. 6). It also gives off the caudal coxal nerve, the caudal femoral cutaneous nerve, and few small muscular branches to innervate into the pelvic limb.

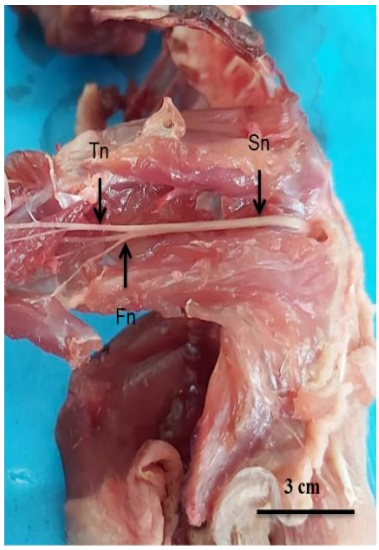

Figure 6. Distinct branches of sacral plexus in domesticated pigeon innervated into musculature. The branches were designated as Sn, sciatic nerve; Tn, tibial nerve; Fn, fibular nerve.

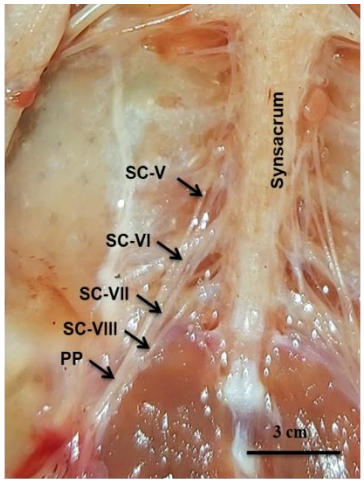

Figure 7. Formation of pudendal plexus in domesticated pigeon showing ventral branches sacro-coccygeal spinal nerves. The roots were designated as SC-V, 5th sacro-coccygeal spinal nerve; SC-VI, 6th sacro-coccygeal spinal nerve; SC-VII, 7th sacro-coccygeal spinal nerve; SC-VIII, 8th sacro-coccygeal spinal nerve; PP, pudendal plexus.

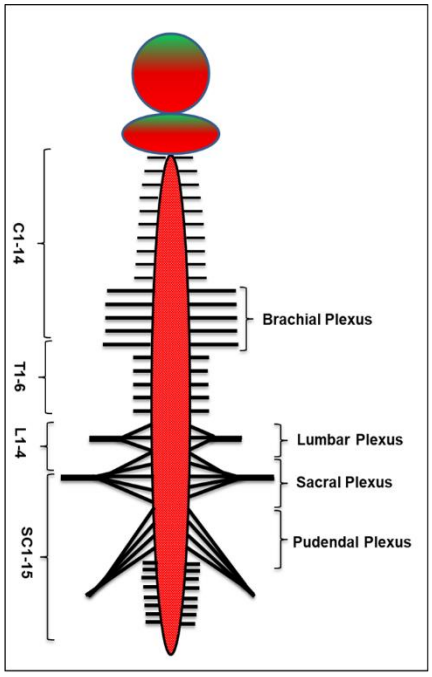

Figure 8. Schematic view focusing on the formation and branches of lumbar, sacral and pudendal plexus in domesticated pigeon of Bangladesh. C 1-14, Cervical spinal nerve 1-14; T1-6, Thoracic spinal nerve 1-6; L1-4, Lumbar spinal nerve 1-4; SC1-15, Sacro-coccygeal spinal nerve 1-15.

Origin and formation of pudendal plexus

The pudendal plexus was compiled with the ventral branches of the fourth, fifth, sixth and seventh sacro-coccygeal spinal nerves. The contribution of small fibers from the third sacro-coccygeal spinal nerve was least and united with the fourth sacro-coccygeal spinal nerves (Fig. 7). The rest of the sacro-coccygeal spinal nerves were innervated into the musculature and other associated structures of the tail.

Discussion

In the present study on pigeons, it was noticed that the lumbosacral plexus consisted of the lumbar and sacral plexus at the either side of the ventral surface of the synsacrum. Here, we observed that the lumbar plexus was compiled with the three ventral roots of spinal nerves, which included the ventral branches of the first lumbar spinal nerves and the ventral branches of the second and third lumbar spinal nerves. These findings are almost similar to the previous findings which reported that the lumbosacral plexus was formed by the branches of the synsacral spinal nerves originating from the ventrolateral aspect of synsacrum (Balkaya et al., 2013). The lumbar and sacral plexus consist of three and four spinal nerves respectively in pigeon (Balkaya et al., 2013). They showed that the lumbosacral plexus is a single nerve plexus with a total number of seven (2-8) spinal nerves where specific ventral roots of the spinal nerve were not determined. In this study, we showed that the lumbar plexus was formed with the specific ventral branches of the first three lumbar spinal nerves. Huber also reported that the lumbar plexus and sacral plexus were mainly formed with the roots of three lumbar and four sacro-coccygeal spinal nerves in pigeon (JF Huber, 1936). Previous report in chicken (Nickel et al., 1977; Dursun, 2007), quail (Fitzgerald, 1969), and rock partridge (Can & Ozdemir, 2011; Can & Ozdemir, 2012) showed almost similar combination where the lumbar plexus was arranged with branches of three spinal nerves. Different findings were also reported where the lumbar plexus was arranged with the branches of four spinal nerves that include three lumbar and one sacral root in the ostrich (El Mahdy et al., 2010) and Japanese quail (Bentley & Poole, 2009). This present study showed that lumbar plexus gives off five large branches that were innervated mostly into the thigh musculature of pigeons. The branches were the cutaneous femoris nerve, coxalis cranialis nerve, femoralis nerve, saphenous nerve, and obturatorius nerve. The cutaneous femoris nerve was innervated into the muscle sartorius, iliotibialis cranialis and skin. The saphenous nerve was supplied to the iliacus muscle. The cranial coxal was a small nerve and innervated the iliotibialis lateralis muscle. Similar innervation patterns were also previously reported in the pigeons (Balkaya & Ozudogru, 2013), chicken (Nickel et al., 1977; Dursun, 2002), Japanese quail, and rock partridge (Can & Ozdemir, 2011; Can & Ozdemir, 2012). Different findings were also reported where three branches in ostrich (El-Mahdy et al., 2010), six branches in

patridges, and Japanese quail (Can & Ozdemir, 2011). In this study, we found that the obturatorius nerve was originated from the middle root of the lumbar plexus. This obturatorius nerve was coursed cuadolaterally parallel to the ventral border of the ilium and passed through the obturaotor foramen. The course of obturatorius nerve was almost similar to the course of obturator nerve in domestic fowl (Baumel, 1979; Breazile & Yasuda, 1979; Vandem Berge, 1979); and duck (Hussan et al., 2018).

In addition, we found that the sacral plexus was mainly organized with the ventral branches of the fourth lumbar and first four sacro-coccygeal spinal nerves. The contribution of the roots of the fourth lumbar and first three sacro-coccygeal spinal nerves was the highest in sacral plexus. The small ventral root originated from the third lumbar and fourth sacro-coccygeal spinal nerves were united with the root of the fourth lumbar and third sacro-coccygeal spinal nerves respectively in sacral plexus. The previous report in poultry showed sacral plexus was organized with the four spinal nerves in pigeon, quail, pheasant and chicken (Balkaya et al., 2013; Huber, 1936; Istanbullugil et al., 2013; Serbest et al., 1993). Different findings were also reported in domestic and wild birds where the sacral plexus consisted of the ventral branches of five spinal nerves in rock partridge (Can & Ozdemir, 2012), six spinal nerves in duck and white turkey (Hussan et al., 2018; Istanbullugil et al., 2008) and seven spinal nerves in the largest wild bird ostrich (EL-Mahdy et al., 2010). We found that the sacral plexus gives off a single large and compact cylindrical bundle of nerve fiber, medial to acetabular foramen which was termed as sciatic nerve and innervated with few small branches into the limb musculature of pigeon. The sciatic nerve was extended and divided into tibial and fibular nerves. The previous report also showed that the sacral plexus was branched into fibular and tibial nerves and made up the sciatic nerve in the pigeons and ducks (Balkaya & Ozudorgu, 2013; Hussan et al., 2018). It was also stated that sacral plexus gives off four branches in quail and rock partridge (Can & Ozdemir, 2011; Can & Ozdemir, 2012).

We also investigated the pudendal plexus which was made up with the branches of the fourth, fifth, sixth, and seventh sacro-coccygeal spinal nerves. The contribution of small fibers from the third sacro-coccygeal spinal nerve was the least and united with the fourth sacro-coccygeal spinal nerve. There was a very limited published report on pudendal plexus in flying birds. Similar findings were also reported in cock where the pudendal plexus was organized with the roots of four spinal nerves (Ohsawa et al., 1991). The overall findings of the formation of lumbosacral and pudendal plexus in domesticated pigeons were depicted in a drawing which is shown in Fig.8.

Conclusion

In this study, we demonstrated the formation of the lumbosacral and pudendal plexus in domesticated pigeons. It can be stated that the formation of lumbosacral and pudendal plexus of domesticated pigeons was conformed to that of other avian species. However, we briefly described some differences in the formation and branches of lumbosacral and pudendal plexus in domesticated pigeons with some common poultry species. These differences may be due to species variation or individual peripheral nervous systems. This was the first investigation on the formation of the lumbosacral and pudendal plexus in domesticated pigeons and the data serve a basis for the further investigation of the neuroanatomy of lumbosacral and tail regions of other avian species.

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Author's contribution

Jahagir Alam: Conceptualizing, planning, dissecting the pigeons, editing photos, manuscript writing and editing. Md. Khalid Hasan: purchased pigeons and photography.

Consent to participate

The authors provide full consent to participate as per need.

Consent for publication

All the authors have full consent to publish this article in Bangladesh Journal of Animal Science.

Conflict of interest

The authors declare no conflict of interest.

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