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ORIGINAL ARTICLE

Investigating the Normal Digestive Canal Ultrasonography of Mature Persian Sturgeon for Providing Standard Approaches

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Abstract

Objective- This study was conducted to make a full understanding of the anatomic and ultrasonographic characteristics of digestive canal in Persian sturgeon and provide standard approaches for performing digestive tract ultrasonography on this sturgeon species.

Design - Experimental study

Animals - 30 mature Persian sturgeons (*Asipencer persicus*) (15 females and 15 males)

Procedures- A potable ultrasonography machine was used and proper approaches were chosen according to the anatomical examination. First the ultrasonography of the organs (out of the body) was carried underwater, then the ultrasonography of the alive fish was done. Finally, dissection was used to compare the anatomy and ultrasonography results.

Results- There are folds on the internal surface of the esophagus. The esophageal wall was thin and hyperechoic with no clear layers. The proventriculus wall was visible as a completely hyperechoic layer in the region where it was attached to ventriculus. The muscular layer of the ventriculus was thicker than that of proventriculus. The pyloric caecum was seen to be located posterior to the ventriculus as a completely hypoechoic layer. The wall layers of the small intestine and spiral colon were comprised of the 4 parts.

Conclusion and Clinical Relevance- The study presented a standard ultrasonography approach for the digestive canal of adult Persian sturgeon. The places of locating probe for digestive ultrasonography are between the pectoral fines for esophagus, liver, ventriculus, proventriculus, proximal part of the right pectoral fine for gallbladder and liver, distal part of the left pectoral fine for ventriculus and pyloric caecum, posterior to the pectoral fines for small intestine, anterior to pelvic fines for small intestine and spiral colon and between pelvic fines for rectum, spiral colon, connection between the rectum and spiral colon.

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1. Introduction

Sturgeons are one of the most important family of fish species found in the Caspian Sea.[18] Persian sturgeon (*Asipencer persicus*) is a very valuable member of this family in Iran. The unfortunate fact is Caspian sturgeon species are today on the verge of extinction. Therefore, the fish culture of these species is considered a matter of great importance. There are increasing reports of gastrointestinal disorders for fish farming practices based on hand feeding,[17] which urgently necessitate finding solutions to identify the common gastrointestinal disorders. Considering the large size of these species as well as the efficiency, cost effectiveness, non-invasive, and availability of ultrasonography, this technique will be a very practical diagnostic approach to such disorders.

Ultrasonography is a highly effective method for soft tissue examination, which also requires a thorough knowledge of the anatomical structure of organs under study.[2-6] Ultrasonography could be used as an effective diagnostic technique.[18] Ultrasonography, as a valuable technique, has many applications in the study of aquatic animals,[13,15] including fishes and marine mammals. This technique is biologically non-hazardous. Sharks may be a great case for ultrasonography for having no mineralized bone and swim bladder full of gas that interferes with the ultrasound wave propagation.[11,16]

The vertebral column of bony fishes is the biggest problem in ultrasonography. In the case of sturgeons, the vertebral column is no problem due to its cartilage structure. Owing to the anatomical location of swim bladder (dorsal of the coelemic cavity), it is not normally regarded as a problem in ultrasonography. However, the disturbing factor in ultrasonic imaging is scutes (bony flat compartments)[7,8,9] of sturgeons on their skin surface as they prevent the ultrasonic waves from passing through the body. This means that ultrasonography should be performed on the parts with minimum cover by bone plaques.[16]

No comprehensive study has been reported to focus on the gastrointestinal ultrasonography of Persian sturgeon. Vajhi *et al*. (2013) studied the digestive system anatomy of Persian sturgeon.[17] Rahmati *et al*. (2011) examined the anatomy and histology of pyloric caeca in two-year-old beluga. They found three functions of pyloric caecum in fish, i.e. storage, fermentation, and digestion. They pointed out that the pyloric caeca are composed of connected parts. The structure is a nearly triangular form in beluga. They also found that pyloric caeca were attached to duodenum by a delicate ligament in the left side and to stomach in the right side, the pancreas was attached to pylorus by a flaccid connective tissue, and the pyloric caeca has a convex dorsal surface rather flat in ventral surface with a serrated edge.[14] Farrel (2007) concluded that the spiral colon accounts for 50-70% of the gastrointestinal tract in length after the stomach. They found that it has a larger diameter than the other parts of the intestine.[1] The different parts of the digestive canal of Persian sturgeon are esophagus, proventriculus, ventriculus, pyloric caecum, small intestine (Descending part, ascending part and distal part), spiral colon, and rectum, respectively.[17]

This study was based on accessing the normal ultrasonography and comparing them with the anatomy of the digestive tract of the *Asipencer persicus*. The present study aimed to present a standard approach to gastrointestinal ultrasonography in Persian sturgeon.

2. Materials and Methods

The study's samples included 30 adult Persian sturgeons (*Asipencer persicus*), which appeared to be healthy, (15 females and 15 males) with an average weight of 21.4±0.5 kg and an average fork length of 139.2±0.72 cm.

Ultrasonography was performed using the Pie Medical 200 VET ultrasound machine (the Netherlands) and a waterproof rectal transducer (animal rectal) with two alternative frequencies (5 and 7.5 MHz, mostly the

former).

All the appropriate approaches to ultrasonography were derived from the anatomical studies of Vajhi *et al*. (2013). It should be noted that one sample was subject to a thorough anatomical examination to provide a better design of the approaches. The other samples were also examined after ultrasonography. The results are shown in Figure 1. The names were used according to those of Vajhi *et al*. (2013).

The first step involved performing ultrasonography on the external organs and inside the water to providing normal images. 10 samples were examined in this step. The digestive canal of the fishes was removed from the trunk by injecting 100 cc water into the intestine with a syringe and a catheter. Then, the samples were placed in the water for ultrasonography, which covered the digestive system from mouth to anus. The fishes were already placed in a container of water in this step.

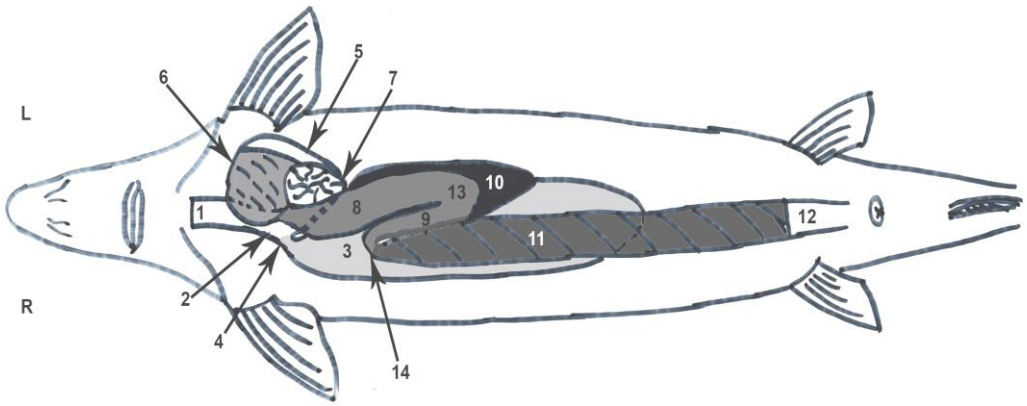

Figure 1. Ventral schematic illustration of the digestive canal of the Persian sturgeon (*Asipencer persicus*) (liver is not illustrated in this figure)**.** 1: Esophagus, 2 Connection between esophagus and proventriculus, 3 Swim bladder, 4: Pneumatic duct, 5: Proventriculus, 6: Stomach (gizzard), 7: Pyloric caecum, 8: Descending part of the small intestine, 9: Ascending part of the small intestine, 10: Spleen, 11: Spiral colon, 12: Rectum, 13: Primary flexure of the small intestine, 14: Secondary flexure of the small intestine.

3. Results

Ultrasonography of the esophagus

There are folds on the internal surface of the esophagus. The esophageal wall was thin and hyperechoic with no clear layers. The esophagus was situated on the midline of the body. The proximal part of the esophagus was adjacent to the heart structures, which were located on the ventral side of the esophagus. The distal part of the esophagus was adjacent to the liver on the ventral side. The anterior and posterior parts were not found to be significantly different through ultrasonography (Figures 1-3). The esophagus was visible between the pectoral fins according to the transverse and left sagittal sonograms (Table 1).

Ultrasonography of the proventriculus

The empty proventriculus was barely visible, and the wall included very thin hyperechoic serosa, hypoechoic muscular layer, and hyperechoic mucosa. The proventriculus wall was visible as a completely hyperechoic layer in the region where it was attached to ventriculus or gizzard (Figure 3). This structure was observed in the left sagittal sonogram of the region between the pectoral fins (Table 1).

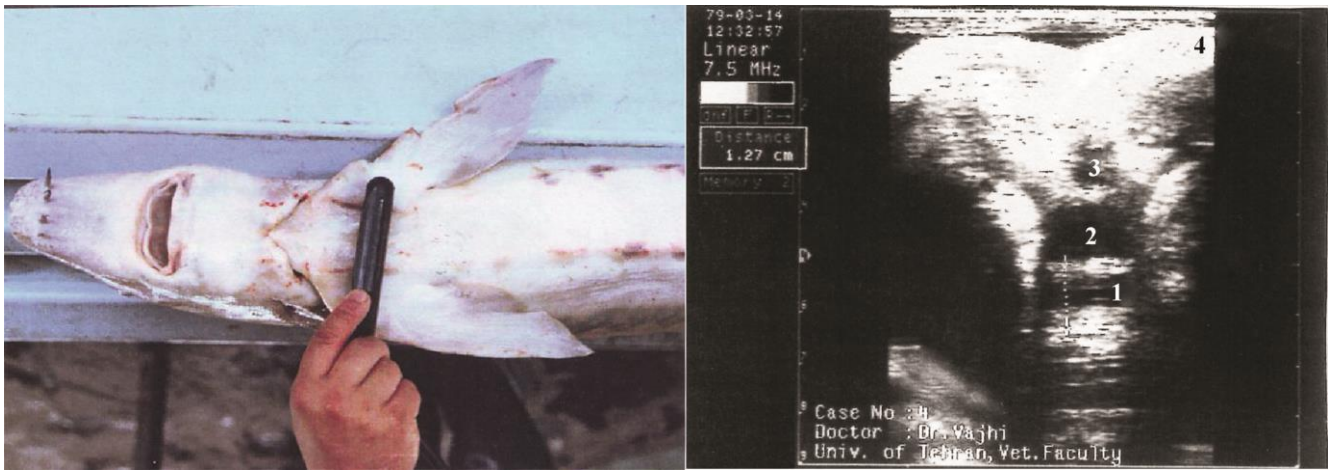

Figure 2. Transverse ultrasonogram from proximal part of the pectoral fines, see approach in the left photo. Persian sturgeon (*Asipencer persicus*). 1: Esophagus, 2: Atrium of the heart, 3: Conus arteriosus of the heart, 4: Ventral septum of the body near the pectoral fines.

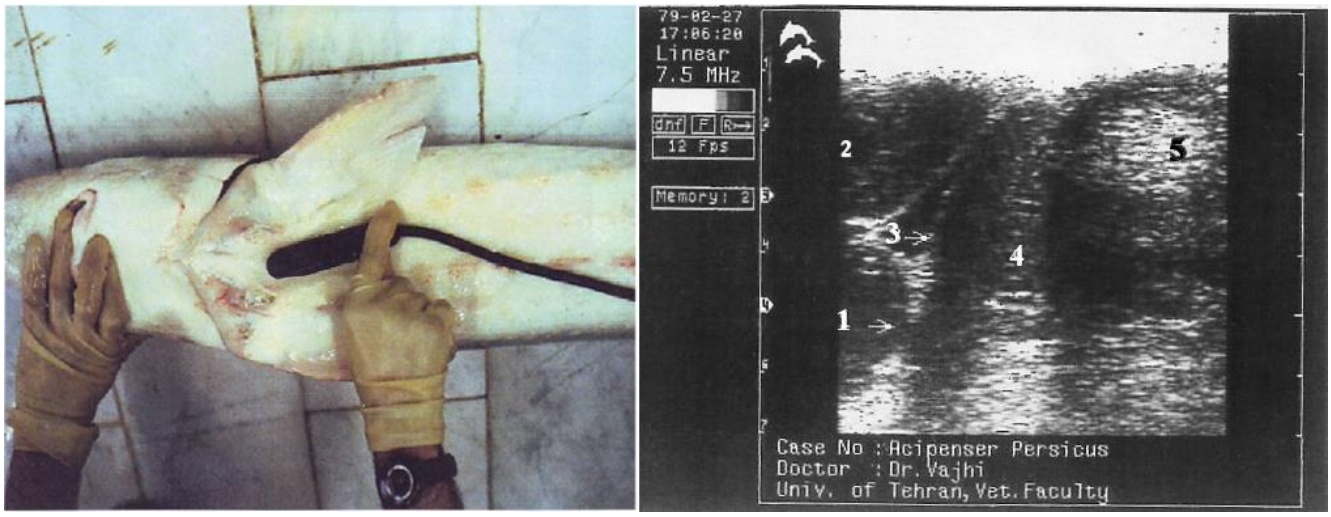

Figure 3. Left sagittal ultrasonogram from proximal part of the left pectoral fine, see approach in the left photo. Persian sturgeon (*Asipencer persicus*). 1: Proventriculus, 2: Heart, 3: Transverse septum, 4: Liver, 5: Ventriculus (gizzard).

Table 1. The places of locating probe for investigating different parts of the digestive canal in the Persian sturgeon (*Asipencer persicus*)

The place of locating probe	Imaging direction	Observable structures
Between the pectoral fines, The most anterior area	Transverse	Esophagus, atrium of the heart, conus arteriosus of the heart
Between the pectoral fines, more posterior than last	Left sagittal	Esophagus, Heart, Transverse septum, Liver, ventriculus (Gizzard), Proventriculus
proximal part of the right pectoral fine	Right oblique and sagittal	Gallbladder and liver
Distal part of the left pectoral fine	Left frontal	Ventriculus and pyloric caecum
Posterior to the pectoral fines	Left sagittal and transverse	Small intestine
Posterior to previous place	Left frontal and transverse	Small intestine and spiral colon
	Right frontal and transverse	Spiral colon
Anterior to pelvic fines	Transverse and left/right frontal	Spiral colon
Between pelvic fines	Sagittal	Genital duct, rectum, gonads, spiral colon, connection between the rectum and spiral colon

Ultrasonography of the ventriculus (gizzard or stomach)

The muscular septum of the ventriculus (gizzard) was thicker than that of proventriculus (Figure 2). This structure was also observed in the left sagittal sonogram of the region between the pectoral fins (Table 1).

Ultrasonography of the liver and gallbladder

The liver tissue was homogeneous in terms of echogenicity and situated anteriorly to the ventriculus. It was hypoechoic as compared to the ventriculus and even more hypoechoic as compared to the transverse septum. The liver and gallbladder were well visible in all the right sagittal and right oblique sonograms with the probe underneath the right pectoral fin. The gallbladder was visible as an echoic layer with the inside materials. Blood vessels were another echoic structure observed in the sonograms (Figure 4) (Table 1).

Ultrasonography of the pyloric caecum

The pyloric caecum was seen to be located posterior to the ventriculus as a completely hypoechoic layer while the details were unclear. The sonogram included acoustic shadowing underneath this structure (Figure 5). The pyloric caecum was observed in the left frontal sonogram through the distal part of the left pectoral fin (Table 1).

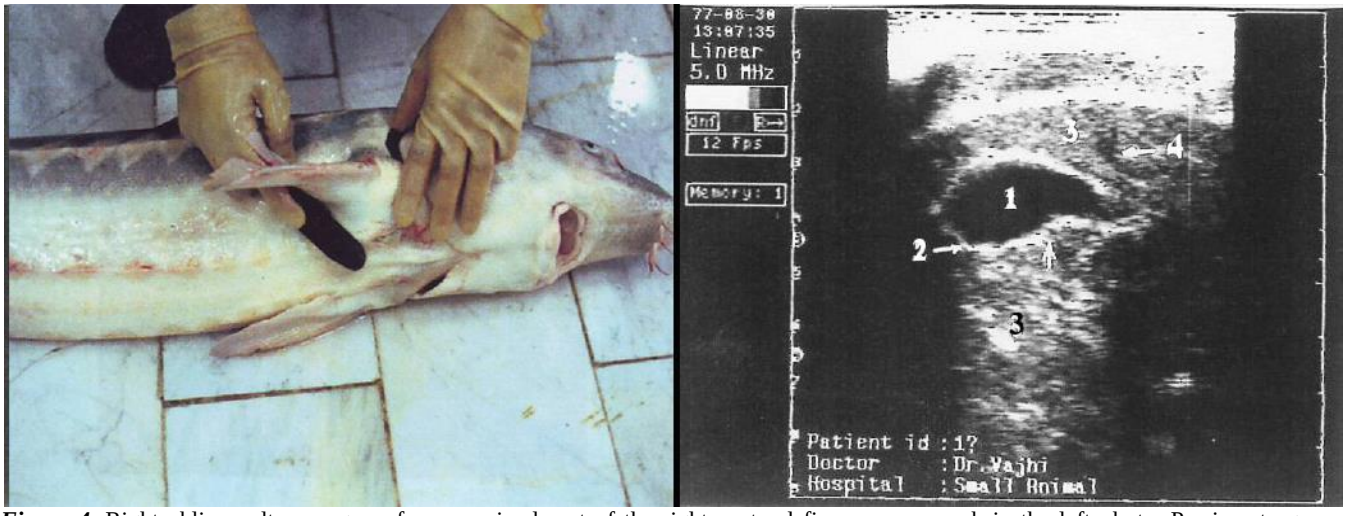

Figure 4. Right oblique ultrasonogram from proximal part of the right pectoral fine, see approach in the left photo. Persian sturgeon (*Asipencer persicus*). 1: Gallbladder, 2: Hyperechoic wall of the gallbladder, 3: Liver (under the gallbladder enhancement artifact is seen), 4: Vessels of the liver.

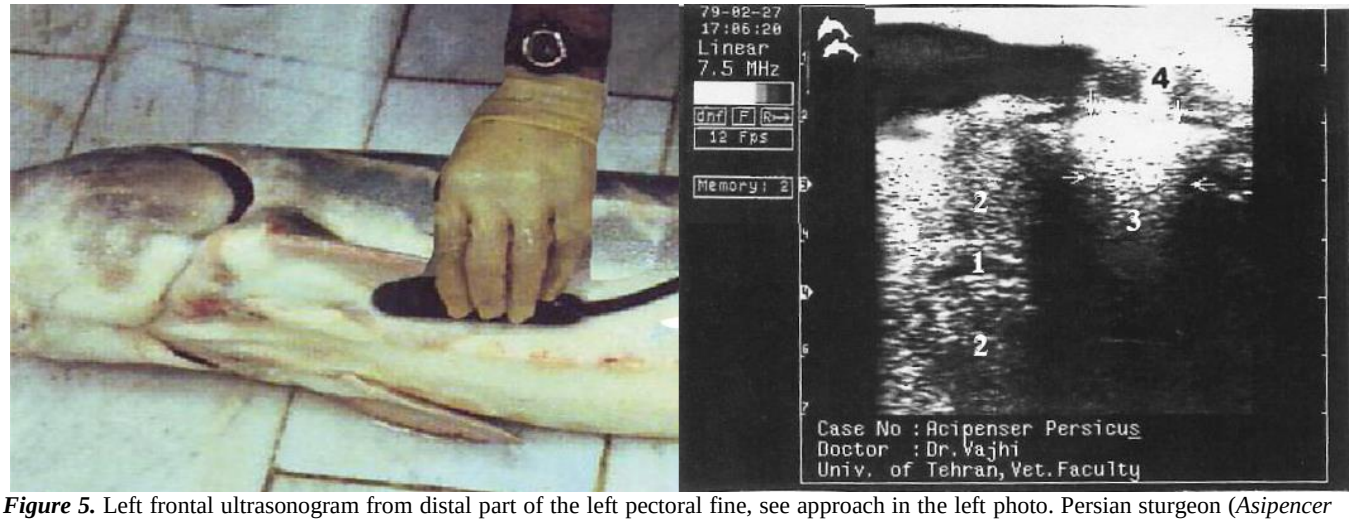

Figure 5. Left frontal ultrasonogram from distal part of the left pectoral fine, see approach in the left photo. Persian sturgeon (*Asipencer persicus*). 1: Lumen of the ventriculus, 2: Wall of the ventriculus, 3: Pyloric caecum, 4: Wall of the body.

Ultrasonography of the small intestine

The small intestine was seen as a whole structure but with parts of different diameters. The wall layers were comprised of the following parts: serous membrane (hyperechoic), muscular layer (fairly thick hypoechoic), submucosa membrane (thin hyperechoic), and mucous membrane (with two distinct echoes: one of a relatively thick hypoechoic layer and the other of a thick hyperechoic layer but with smaller echogenicity than those of serosa and sub mucosa) (Figure 6). The muscles of distal part of small intestine were very smaller in number, whereas those of the descending one exhibited a larger number than the other two parts of the small intestine. Probe was placed left frontally and transversely on the caudal to the pectoral fin to ultrasonography in a left frontal/transverse arrangement to examine the small intestine (Table 1). The small intestine was partly visible when the probe was placed in the posterior region of the pectoral fins, while the other parts and the spiral colon became visible after moving the probe towards the caudal part.

Ultrasonography of the spiral colon

The wall layers of spiral colon consisted of the following: serosa (thin hyperechoic), muscular layer (fairly thick hypoechoic), submucosa (thin hyperechoic), and mucosa (faintly thick isoecho with the previous layer). A cellular from was seen inside the lumen due to the folded structure of the intestine (Figure 7). In transverse ultrasonography, the important point was to observe the typhosol structure and the mucous sheath connecting it to the lumen wall (Figure 8). In transverse ultrasonography, an edge shadow artifact was observed in some cases due to the large volume of wall muscles. In transverse and frontal ultrasonography, some of the layers were not visible, especially those underneath the mucosa and the region between the mucosa and lumen if there was no prior fluid injection into the lumen. The spiral colon was visible in the left and right frontal ultrasonography of anterior region to the pelvic fins (Table 1).

Ultrasonography of the rectum

The following layers were observed in the rectum wall through median ultrasonography: serosa (thin hypoechoic), muscular layer (thin hypoechoic), and mucosa (hyperechoic). The region between the mucosa and lumen was sometimes visible as a hypoechoic layer. The following structures were visible through sagittal ultrasonography of the region between the pelvic fins: rectum, spiral colon, the connection between the rectum and the spiral colon, gonads, and genital ducts. The genital ducts were visible as an anechoic layer adjacent to the rectum (Figure 9) (Table 1). There was also a common duct, consisting of the connected right-left genital ducts, visible underneath the rectum by moving the probe closer to the anus.

4. Discussion

Esophagus

According to Vajhi *et al*. (2013), there are longitudinal folds and many mucosal papillae on the inner surface of the esophagus of Persian sturgeon. These longitudinal folds are not typically visible through ultrasonography.[17] Vajhi *et al*. (2013) added that the inner surface of the esophagus has numerous mucosal papillae, which play a role in carrying food through the digestive system. These papillae of different sizes divide the esophagus into two parts, anterior and posterior. In the anterior part, there are many conical and long papillae scattered on the surface and facing the posterior. In the posterior part, there are delicate and short papillae in a smaller area. However, this difference was not observed by ultrasonography.[17] According to the results of this study, it can be concluded that the transverse and left sagittal approach can be performed on the interpectoral fins region for ultrasonography of the esophagus of Persian sturgeon.

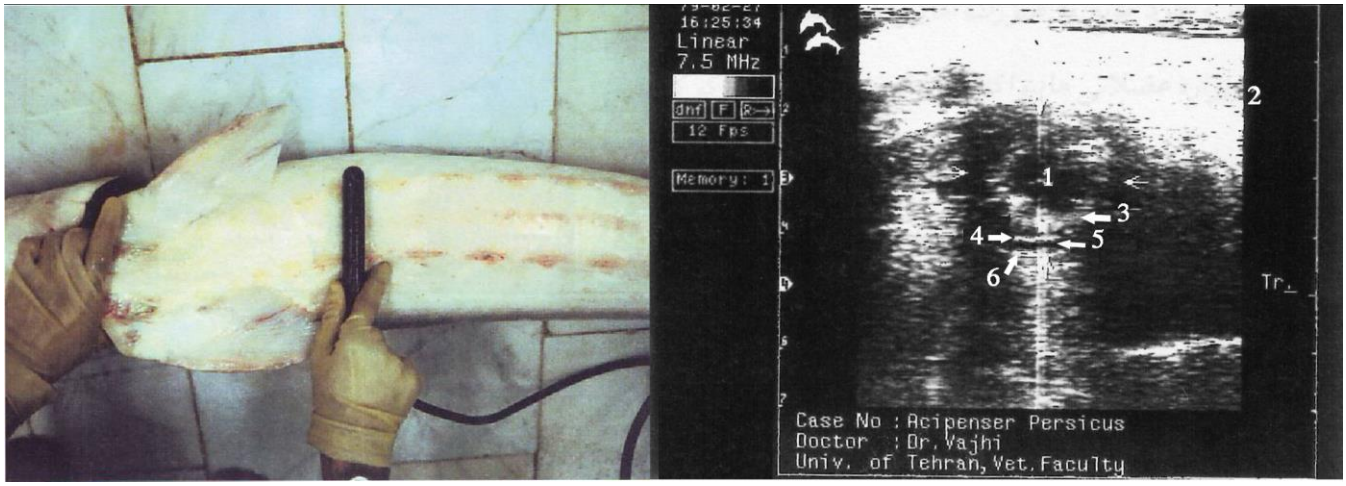

Figure 6. Transverse ultrasonogram from caudal part of the pectoral fines, see approach in the left photo. Persian sturgeon (*Asipencer persicus*). 1: Lumen of the small intestine, 2: Wall of the body, 3: Mucous membrane, 4: Sub mucous membrane, 5: Muscular layer, 6: Serous membrane.

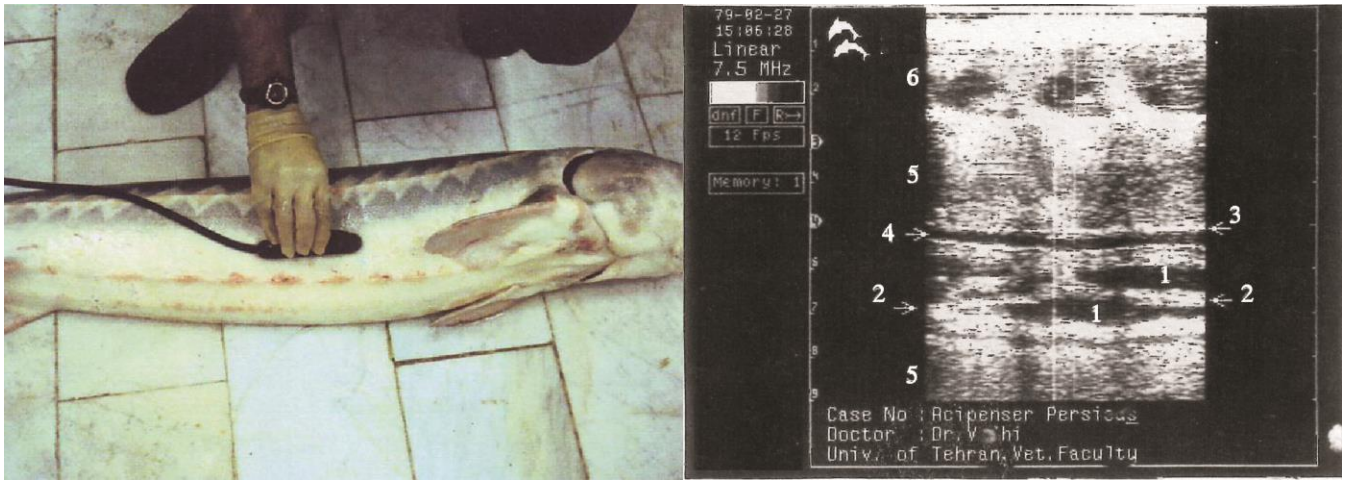

Figure 7. Right frontal ultrasonogram from anterior to the pelvic fines (posterior to Figure 6), see approach in the left photo. Persian sturgeon (*Asipencer persicus*). 1: Lumen of the spiral colon, 2: Mucous membrane, 3: Serous membrane, 4: Muscular layer, 5: Gonads, 6: Wall of the body.

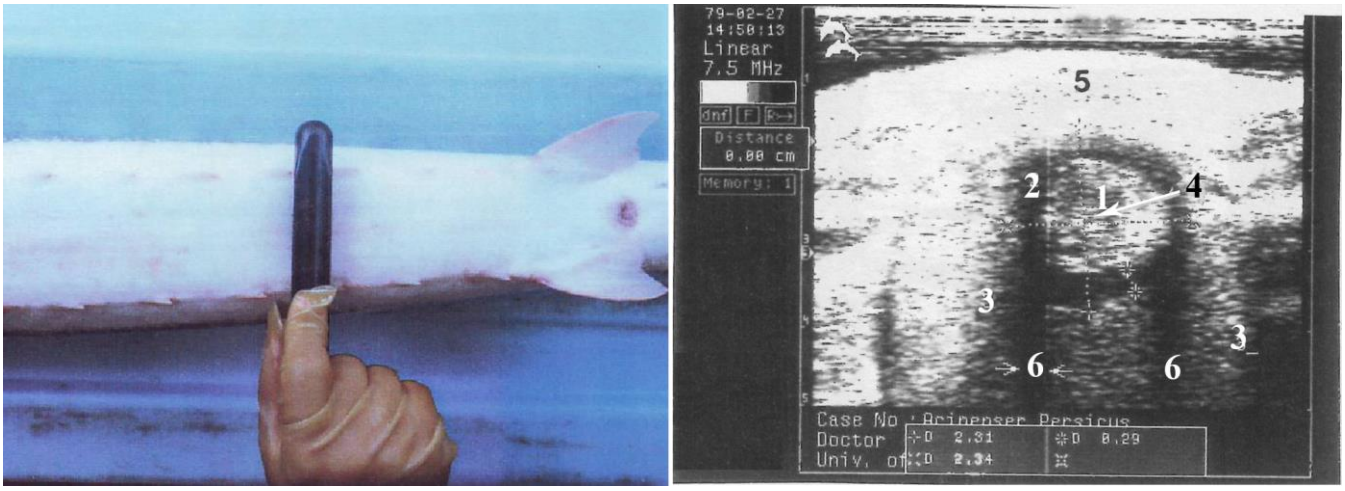

Figure 8. Transverse ultrasonogram from anterior to the pelvic fines (posterior to Figure 7), see approach in the left photo. Persian sturgeon (*Asipencer persicus*). 1: Lumen of the spiral colon, 2: Muscular layer, 3: Gonads, 4: Typhosol, 5: Wall of the body, 6: Edge shadow artifact.

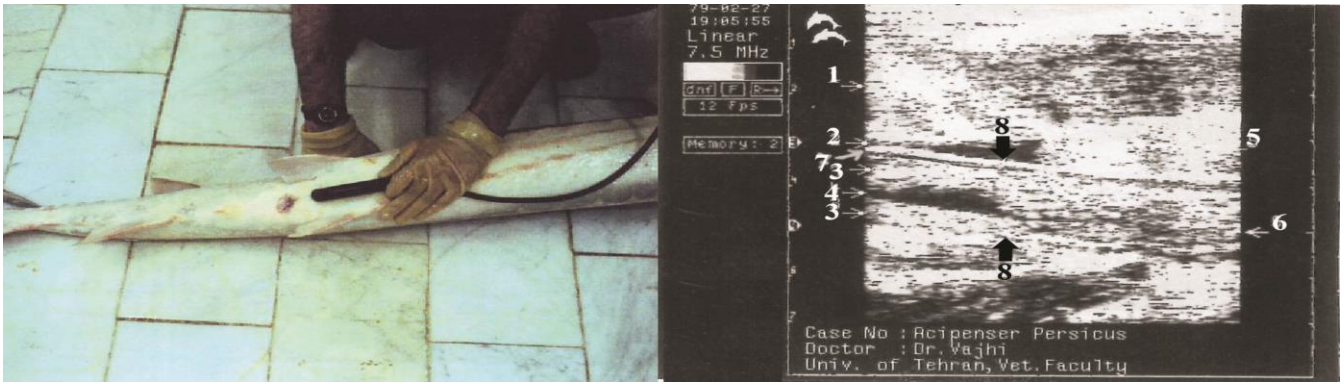

Figure 9. Sagittal ultrasonogram between pelvic fines, see approach in the left photo. Persian sturgeon (*Asipencer persicus*). 1: Wall of the body, 2: Genital duct, 3: Mucosa of the rectum, 4: Lumen of the rectum, 5: Gonad, 6: Mucosa of the spiral colon, 7: Serosa of the rectum, 8: Connection between the rectum and spiral colon

Proventriculus and ventriculus

According to Vajhi *et al*., (2013), the stomach has two parts; the first part, or proventriculus, is a U-shaped structure stretched from the end of the esophagus to ventriculus. This part has a thin muscular septum. In addition, the proventriculus is connected to the ventriculus on the left side. In this study, the connection region was visible as a completely hyperechoic layer.[8,16,17]

Next to the U-shaped part, there is one of the lobes of the liver. The ventriculus tissue is easily distinguished from the esophagus macroscopically.[8.16.17] The ventriculus has longitudinal folds. It is roughly equal in diameter to the esophagus. It has no papillae but exhibits fairly thick longitudinal folds.[17,16] In this study, the esophagus was distinguishable from the proventriculus through ultrasonography.

According to the results of this study, it can be concluded that the left sagittal approach can be performed on the interpectoral fins region for ultrasonography of the proventriculus of Persian sturgeon.

The second part of the stomach is ventriculus, also known as gizzard or pyloric part.[8,10,16] Vajhi *et al*. (2013) showed that this spherical organ has thick muscles and the same size as the clenched fist but smaller than proventriculus in length. It is situated between the proventriculus and small intestine. Ventriculus is exactly located on the dorsal surface of the liver, mostly surrounded by the liver lobes, particularly the left and right lobes.[17,16]

The inner surface of ventriculus has no folds but exhibits a velvet-like structure[17]. There is a small prominent in the front end of the ventriculus, which separates this part from the proventriculus. This was visible as a completely hyperechoic layer in ultrasonography. The pyloric sphincter is located at the end of the gizzard.[17,16] The muscular layer of the wall of this organ was found to be thicker than proventriculus through ultrasonography.

According to the results of this study, it can be concluded that the left sagittal approach can be performed on the interpectoral fins region for ultrasonography of the ventriculus of Persian sturgeon.

Liver and gallbladder

Vajhi *et al*. (2013) found that the ventral part of the liver covers the ventriculus of Persian sturgeon. This organ is located after the wall that separates the pericardial cavity from the coelomic cavity in the anterior part of the muscular stomach.[17,16] The right side of the ventriculus is partly surrounded by the liver. The liver has three lobes. The right lobe is located on the lateral border of the small intestine and covers the ventriculus.[17,16] The left lobe is located between the lateral regions of proventriculus. The last and smallest lobe is the middle lobe located between the ventriculus and small intestine and connected to the pyloric caecum. The right lobe is much bigger than the left lobe,[8,16] stretched to the back end of pectoral fin, while the left lobe is stretched only to the end of the region where the

pectoral fin is attached. Another part of the liver is on the left of the descending small intestine and the other lobe is on the dorsal surface of the bend of the U-shaped stomach. The gallbladder is a bubble-shaped sac on the cranioventral part of the liver right lobe.[17,16] The liver and gallbladder were well visible in all the right sagittal and right oblique sonograms with the probe located underneath the right pectoral fin. Blood vessels were another echoic structure observed in the sonograms.

Pyloric caecum

According to Vajhi *et al*. (2013), there is a sponge-like, triangular, and flat structure named "pyloric caecum" at the region of the opening of the ventriculus to the small intestine. It is topographically located on the left side bottom of the ventriculus. This structure comprises several lobes.[8,16,17] It was found to be located in the posterior ventriculus as a completely hypoechoic layer and the details were unclear in the sonogram, which also included acoustic shadowing underneath the structure.

According to the results of this study, it can be concluded that the left frontal approach can be performed on the distal part of the left pectoral fin region for ultrasonography of the pyloric caecum of Persian sturgeon.

Small intestine

Vajhi *et al*. (2013) showed that the small intestine is generally very short with a bent sac stretched from the pylorus to the spiral colon. It has two flexures, i.e. primary and secondary flexures, which separate it to three parts named the descending, the ascending, and the distal part.[8,16,17] The descending small intestine is stretched from ventriculus to primary flexure while the ascending one is stretched from the primary to secondary flexure.[17,16] In ultrasonography, the small intestine was seen as a whole structure but with parts of different diameters. The examination showed that the muscular layer at the end of the small intestine is very thin and the descending part is thicker than the other two parts of the small intestine.

According to the results of this study, it can be concluded that the left frontal and transverse approach can be performed on the caudal region to the pectoral fins for ultrasonography of the small intestine of Persian sturgeon.

Spiral colon

Vajhi *et al*. (2013) found that the spiral colon is the longest part of the digestive canal located in the midline of the coelomic cavity under the swim bladder, stretched from the end of the small intestine to the rectum. This is a completely straight structure with no flexures.[17] It has mucosal spiral septum stretched from the intestine surface into the lumen. This mucosal septum has collapsed on them, shaping a central rope. The tip of this septum bends over itself and forms a spiral shape.[17,16]

The frontal sonograms provided a longitudinal image of the spiral intestine. A cellular from was seen inside the lumen due to the folded structure of the intestine. In transverse sonograms, the important point was to observe the typhosol structure and the mucous sheath connecting it to the lumen wall. An edge shadow artifact was also obsrerved in some cases due to the large volume of wall muscles.

According to the results of this study, it can be concluded that the left and right frontal approach can be performed on the anterior region to the pelvic fins for ultrasonography of the spiral colon of Persian sturgeon.

Rectum

According to Vajhi *et al*. (2013), the rectum of Persian sturgeon is stretched from the spiral colon to the anus. It is topographically situated on the midline of the body. The muscular layer of the rectal wall is very thin and small in diameter, which gives it a loose appearance. The rectal ultrasonography exhibited an anechoic layer for genital ducts after the skin and muscle at the region where it is connected to the spiral colon. In this region, the distal end

of gonads is usually visible.[12,17,16] There is a significant difference between rectum and spiral colon in terms of wall diameter. The two left and right genital ducts are adjacent to the rectum and well visible at the top of the rectum after the junction of the left and right ducts.[12,17,16]

According to the results of this study, it can be concluded that the left and right sagittal approach can be performed on the interpelvic fins region for ultrasonography of the rectum of Persian sturgeon.

According to this study the places of locating probe for digestive ultrasonography are between the pectoral fines for esophagus, between the pectoral fines, more posterior than last for esophagus and liver, proximal part of the right pectoral fine for gallbladder and liver, distal part of the left pectoral fine for ventriculus and pyloric caecum, posterior to the pectoral fines for small intestine and spiral colon, anterior to pelvic fines for spiral colon and between pelvic fines for genital duct, rectum, gonads, spiral colon, connection between the rectum and spiral colon.

The study's observations suggest that ultrasonography is an effective technique for gastrointestinal examination of sturgeon species. The study showed great consistency between the findings of gastrointestinal ultrasonography and the anatomy of the related structures. The study also presented a standard ultrasonography approach for the digestive canal of adult Persian sturgeon. These findings are useful for identifying fish diseases and disorders such as gastrointestinal foreign objects, neoplasia, inflammatory-based tissue alterations, intestinal obstruction, and so forth.

Conflict of Interests

None.

References

1. Farrell AP. Cardiovascular Systems in Primitive Fishes, *Fish Physiol*ogy, 2007, 26: 53-120.
2. Goddard PJ. Veterinary Ultrasonography. CABI, London, UK, 1st edition, 1995, pp: 289-302.
3. Gregory JA, Graham JB, Cech JJ, Dalton N, Michaels J, Lai NC. Pericardial and pericardioperitoneal canal relationships to cardiac function in the white sturgeon (*Acipenser transmontanus*). *Comparative Biochemistry and Physiology - Part A*, 2004, 138: 203– 213.
4. Icardo JM, Colvee E, Cerra MC, Tota B. The Structure of the Conus Arteriosus of the Sturgeon (*Acipenser naccarii*) Heart. I: The Conus Valves and the Subendocardium. *Anatomical Record*, 2002, 267: 17–27.
5. Icardo JM, Colvee E, Cerra MC, Tota B. The Structure of the Conus Arteriosus of the Sturgeon (*Acipenser naccarii*) Heart: II. The Myocardium, the Subepicardium, and the Conus-Aorta Transition. *Anatomical Record*, 2002, 268: 388–398.
6. Icardo JM, Guerrero A, Duran AC, Colvee E, Domezain A, Sans-Coma V. The Developmental Anatomy of the Heart of the Sturgeon *Acipenser naccarii*. Biology, Conservation and Sustainable Development of Sturgeons. Springer Science, 1st ed, Bern, Switzerland, 2009, pp: 137-152.
7. Iuliis GD, Pulera D. The Dissection of Vertebrates, Academic Press, 2nd edition, Ontario, Canada, 2011, pp: 27-79.
8. Kapoor BG, Khanna B. Ichthyology handbook. Springer Science, 1st edition, Berlin, Germany, 2004, pp: 249-308.
9. Kardong K. Vertebrates: Comparative Anatomy, Function, Evolution. McGraw-Hill Education, 6th edition, New York, USA, 1998, pp: 287-656.
10. King GM, Custance DRN. Colour atlas of vertebrate anatomy. Ferdowsi university press, 1st edition, Mashhad, Iran, 1994, pp: 33-42.
11. Lai NC, Dalton N, Lai YY, Kwong C, Rasmussen R, Holts DB, Graham J. A comparative echocardiographic assessment of ventricular function in five species of sharks. *Comparative Biochemistry and Physiology - Part A*, 2004, 137: 505-521.
12. Moghim M, Vajhi AR, Veshkini A, Masoudifard M Determination of Sex and Maturity in *Acipenser stellatus* by Using Ultrasonography. *Journal of Applied Ichthyology*, 2002, 18(4-6): 325-328.
13. Muñoz-Chápuli R, Pérez-Pomares JM, Macías D, García-Garrido L, Carmona R, González-Iriarte M. The epicardium as a source of mesenchyme for the developing heart, *Italian Journal of Anatomy and Embryology*, 2001, 106: 187-196.
14. Rahmati holasoo H, Najafi GR, Seyrafi R, Ebrahimzadeh Mousavi HA, Shokrpoor S, Ghadam M, Ramzani S. Anatomical and histological investigation of the pyloric caeca in beluga (*Huso*

huso), *Aquaculture, Aquarium, Conservation & Legislation*, 2011, 4(3): 261-267.

15. Sun L, Lien CL, Xu X, Shung KK. In vivo cardiac imaging of adult zebrafish using high frequency ultrasound (45-75 MHz), *Ultrasound in Medicine and Biology*, 2008, 34: 31-39
16. Vajhi AR, Masoudifard M, Moghim M, Veshkini A, Zehtabvar O. Ultrasonography of the sturgeons for sex and maturity determination, University of Tehran press, Tehran, Iran, 2011, pp: 39-58.
17. Vajhi AR, Zehtabvar O, Masoudifard M, Moghim M, Akhtarzade M. Digestive system anatomy of the Acipenser persicus: New features, *Iranian Journal of Fisheries Sciences*, 2013, 12(4): 939-946.
18. Zehtabvar O, Vajhi AR, Tootian Z, Masoudifard M, Sadeghinezhad J, Davudypoor S. Echocardiography and histology evaluation of the heart in the immature (2.5 years old) beluga. *Journal of Veterinary Research*, 2018, 72(4): 467-473.

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چکیده

مطالعه اولتراسونوگرافی طبیعی لوله گوارش تاس‌ماهی ایرانی بالغ برای ارائه رهیافت استاندارد

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هدف: این مطالعه با هدف دستیابی به شناختی درست از ویژگی‌های کالبدشناسی و اولتراسونوگرافی لوله گوارش قره‌برون و ارائه روشی استاندارد برای انجام اولتراسونوگرافی لوله گوارش در این گونه انجام شد.

طرح مطالعه: مطالعه تجربی

حیوانات: ۳۰ عدد تاس‌ماهی ایرانی (*Asipencer persicus*) بالغ (۱۵ ماده و ۱۵ نر)

روش کار: برای انجام این مطالعه از دستگاه اولتراسونوگرافی قابل‌حمل استفاده شد و رهیافت‌ها بر اساس مطالعات کالبدشناسی انتخاب شدند. در ابتدا اولتراسونوگرافی اندام‌ها خارج از بدن، داخل آب و سپس اولتراسونوگرافی نمونه‌های زنده انجام گرفت. درنهایت با مطالعه کالبدشناسی مقایسه آناتومی طبیعی و تصاویر اولتراسونوگرافی انجام شد.

نتایج: در سطح داخلی مری چین‌هایی مشاهده شد. دیواره مری نازک و هایپراکوییک بود و لایه‌بندی مشخصی نداشت. دیواره پیش‌معده به‌صورت یک لایه کاملاً هایپراکوییک در محل اتصال به معده مشاهده شد. بخش عضلانی دیواره معده از پیش‌معده ضخیم‌تر بود. سکوم پیلوری نسبت به معده خلفی‌تر بود و به‌صورت لایه‌ای هایپواکوییک با جزییات نامشخص مشاهده شد. لایه‌های دیواره روده باریک و روده مارپیچ ۴ بخش بود.

نتیجه‌گیری و کاربرد بالینی: در این مطالعه روش استاندارد اولتراسونوگرافی لوله گوارش تاس‌ماهی ایرانی بالغ ارائه شد. این نواحی محل قرار دادن پراب برای اولتراسونوگرافی لوله گوارش هستند: بین باله‌های سینه‌ای برای مری، کبد، پیش‌معده و معده، بخش پروگزیمال باله سینه‌ای راست برای کبد و کیسه صفرا، بخش دیستال باله سینه‌ای چپ برای معده و سکوم پیلوری، خلف باله‌های سینه‌ای برای روده باریک، قدام باله‌های لگنی برای روده مارپیچ و روده باریک و بین آن‌ها برای رکتوم، روده مارپیچ، ارتباط بین رکتوم و روده مارپیچ.

واژه‌های کلیدی: تاس ماهی ایرانی، لوله گوارش، اولتراسونوگرافی، کالبدشناسی