e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com doi: 10.25258/ijpqa.16.4.27

International Journal of Pharmaceutical Quality Assurance 2025; 16(4); 146-150

Original Research Article

Tale of Beaver Tailed Liver

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Received: 20-02-2025 / Revised: 19-03-2025 / Accepted: 20-04-2025
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Conflict of interest: Nil

Abstract:

Introduction: Liver presents with multiple variation with respect to lobes, fissure etc. Beaver tail liver is a tongue shaped elongated variant of the left lobe that is usually fused with the spleen at its capsule. This variant presents with no abnormal symptoms or functions hence its development, morphology and clinical significance has been studied upon.

Materials and Method: During routine dissection of 34 liver specimens, two livers presented with the morphological elongated left lobe variant encircling the spleen, classified under Netters as type 4 Beaver tail liver. Dimensions of elongated lobe was recorded and vasculature was dissected.

Results: The elongated left lobe of the 2 livers measured 16.25 cm and 14.13cm respectively with a smooth brownish black appearance encircling the spleen fused at the capsule presenting with type II Nakamura Portal vasculature and an accessory hepatic artery with different origins to supply the elongated left lobe.

Conclusion: Beaver tail liver is accidentally discovered during a CT/MRI scan and is misdiagnosed as splenic mass, subcapsular hematoma or hepatosplenomegaly. The lack of symptoms, unique vasculature, normal histology and no effect to physiological function indicates it a congenital formation and its larger liver volume makes it suitable for live liver transplants as it reduces recovery time of the donor.

Introduction

Liver a large wedge shaped abdominal viscera present between the right hypochondriac and extending into the epigastric region which develops in 3rd week of IUL [1]. It performs a wide range of function such as detoxification, synthesis of immunoglobulins, coagulation factor and is storage organ of glucose, lipid, vitamins and iron. It is the main site of hemopoiesis during fetal life from 10th week of IUL till end of third trimester.

The morphological variation of liver like accessory lobes, agenesis of lobes, accessory fissures are at a rate of 2-4% globally [2]. Morphological anomalies are common in right lobe such as Reidel lobe whereas rare in left lobe except an elongated tongue shaped left lobe called Beaver tail liver with an incidence rate of 12.5%.[3]

Beaver tail liver or sliver of liver is a morphological elongated anomaly of left lobe crossing the midline, reaches the spleen, fuses at its capsule and may or may not encircle it. This variant presents with no symptoms, physiological differences and is accidently discovered during a CT or MRI scan of the abdomen and misdiagnosed as pericapsular or subcapsular hematoma, splenic mass or hepatosplenomegaly [4, 5].

Methodology

During routine dissection of 34 formalin preserved liver specimens in the Department of Anatomy at Dr B R Ambedkar medical college, two liver specimens obtained presented with a beaver tail variant. The dimensions of the elongated variant were recorded and blunt dissection was conducted to study its vasculature.

Results

The elongated lobes were brownish black, smooth texture measuring to be 16.25 cm and 14.13 cm respectively and fused at the Glisson's capsule and splenic capsule. The right lobe presented with an accessory fissure and it was noted that both had accessory hepatic arteries each with different origin supplying the elongated lobe. Blunt dissection revealed a type II portal vein variation where the left portal vein branch and drained by left hepatic vein while the right was supplied by the normal hepatic artery and right portal venous branch and drained by right and middle hepatic vein.

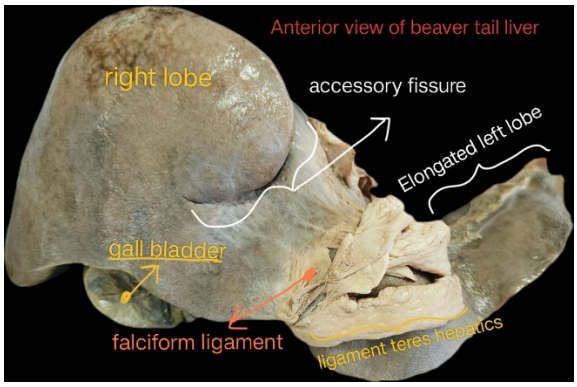


Figure 1: Anterior view of Beaver tail liver

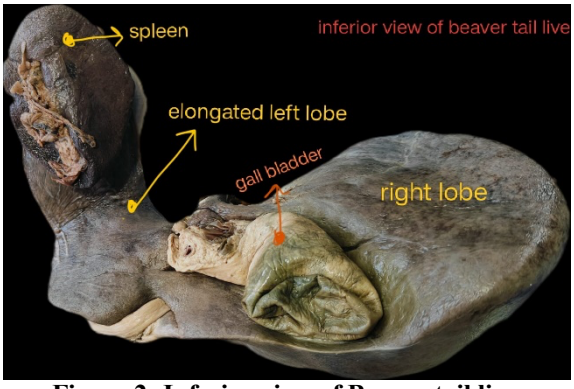
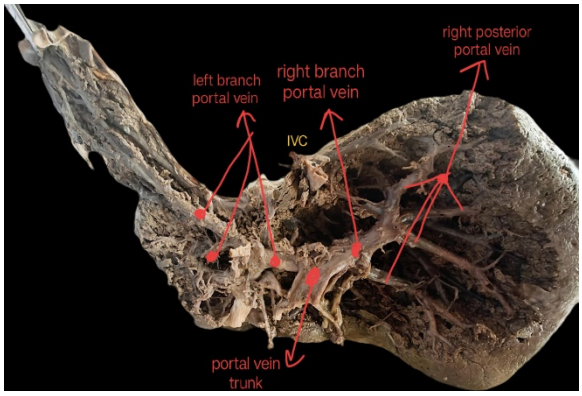
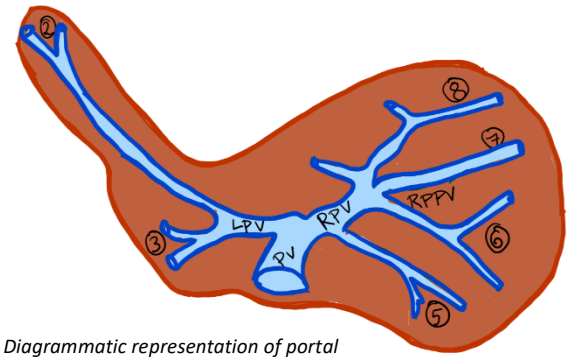


Figure 2: Inferior view of Beaver tail liver





Diagrammatic representation of portal

Figure 3: Type II portal venous vasculature in Beaver Tail Liver.
PV: - portal vein; LPV: - left portal vein; RPV: - right portal vein; RPPV: - right posterior portal vein

Discussion

Beaver tail/sliver liver is an elongated left lobe anomaly crossing the midline to reach the spleen and encircles it. Our study results showed that the elongated left lobe coursing below the left cupola of the diaphragm, anterior to the abdominal esophagus and into the gastrosplenic ligament where it fuses bluntly with the splenic capsule along the diaphragmatic surface which couldn't be separated on blunt dissection, all of which were similar to three previously reported cases of hepatosplenic fusion by AK Pal, Blakaj and Cotelingam.

Anugragha P [3], Vinay S and Padamjeet P [10] reported cases of Hiding Beaver tail liver a variant in which the tail is more acutely angled with the right lobe of the liver and is juxtaposed against the visceral surface of the spleen. The histological examination of the beaver tail liver was first conducted by Cotelingam and later by A K Pal, Blakaj revealed that these variants were of normal hepatic parenchyma separated from the normal splenic parenchyma by a thick fibrous capsule with no features of trauma, inflammation, or scarring which we were able to also demonstrate in this study. [11, 12]

Etymology

Earliest report of Beaver tail liver anomaly was by L J Hammond in 1893 during a tumor excision surgery of a 16yr old girl, he found an elongated left lobe extended across the lesser curvature of the stomach with flattened out at extremity over the spleen. The capsule was normal, no nodule nor any pathological abnormalities. He was unable to repair the anomaly because it caused difficulty for diaphragmatic movement. Post surgery the girl had no other symptom and normal blood report lead him to give a theory that the anomaly development could be congenital [6].

Cotelingam's 1975 reported case of hepatosplenic fusion with Beaver tail anomaly, explained the liver and spleen had fused and had respective histologically normal appearance on either side of the septum separating them and had no evidence of inflammation leading him to theorize that the development was congenital [7]. There was paucity in literacy until in 2015 Shabana Sultana [8] gave the first detailed description of the beaver tail liver and its name was coined in 2017 by Mohammed SF [9] due to its shape resembling that of a Beaver's tail which are flat and broad, assisting beavers to carry

wood for dam construction along rivers, earning them the title nature's architect.

Vasculature of Beaver tail liver

Our Beaver tail liver specimens were supplied by a main hepatic artery and also an accessory hepatic artery supplying only the elongated left lobe originating from the left gastric artery and the coeliac trunk of abdominal aorta which has not been previously reported.

Sam F and Jacob J case report on combined Reidel and Beaver tail variant in the liver had explained the vasculature supply of the anomaly and found that the Beaver tailed left lobe was supplied by the left portal vein and drained by the left hepatic vein into inferior vena cava [13]. Our study found that portal vasculature was of Type II variant according to Nakamura portal vein Classification [14] in which the left lobe was supplied by left portal venous branch and drained by the left hepatic vein and the right lobe was supplied by the right portal venous branch and drained by the right and middle hepatic veins contrast to normal liver where left lobe is drained by left and middle hepatic vein and the right lobe is drained by the right hepatic vein. This variation in venous drainage could be the result of developmental modification during formation of the beaver tail liver to support the blood supply after initiation of portal circulation.

Anugragha P theorized that at birth, cessation of placental circulation and induction of portal vein circulation majorly affects the left lobe making it the first 'victim' of anoxia leading to its regression and said that in Beaver tail liver variant if the vascular channels are formed during development they may prevent this regression [3]. This can be explained by the type II portal vein variation of the Nakamura Classification, where angle between the trunk and the left branch of the portal vein is reduced than normal as a result of a developmental modification of the vitelline veins allowing sufficient blood flow to supply this anomaly.

Theory for development of the Beaver tail anomaly: Lagman's embryology describes liver development beginning during the 3rd week of intrauterine life as 2 hepatic buds at distal end of foregut that ascends towards the septum transversum. Even though all the endodermal cells in the foregut have the potential to express liver specific genes they are suppressed by factors; fibroblast growth factor-2 (FGF 2) secreted by cardiac mesoderm, bone morphogenetic protein (BMP) by septum transversum and Hepatocyte nuclear transcription factor HNF 3-4 [15] which instruct the liver cells to differentiate into hemopoietic cells, Kupffer cells and connective tissue. During 8th week of intrauterine life, the vitelline veins invade the septum transversum where they are interrupted by the growing liver cords resulting in formation of hepatic sinusoids, reduction of left sinus horn result to form the portal vein. During fetal life the left lobe its function of hematopoiesis is supported by the left umbilical vein that shunts oxygenated blood from umbilical vein into IVC.

The normal histological findings by Cotelingam, A K Pal, P Baruah, and absence of clinical symptoms by Hammond lead them to theorize a congenital genesis of beaver tail variant. Cotelingam hypothesized that the hepatic and splenic anlagen separated by delicate connective tissue about the fourteenth week of IUL during rotation if they anatomically approximate it would explain the initial event of fusion between them and added on by AK Pal's article that the subsequent growth of the fused organs post rotation of liver might have resulted in the elongated tongue shaped left hepatic lobe therefore not strictly qualify as an accessory left hepatic lobe. [12, 7]

Our Theories for Approximation: Hypertrophy of fetal liver to compensate for complications of inflammation due to infection or hypoxia due to anemia result of dietary deficiency like iron deficiency prior to 12th week could favor the approximation of liver and spleen anlagen resulting in their fusion. The hypertrophy also explains the accessory fissure which would have developed as result of diaphragmatic impact. The events of fusion of liver and spleen each with normal parenchyma could be due to the epithelial-mesenchymal interactions guarded by the factors FGF-2 and HNF-3 for normal liver development and Hox11, Spi-C, Pbx1 for normal spleen development in vivo [16]. They being separated by a thick capsular margin indicates that post approximation of the spleen and liver the surrounding mesodermal tissue formed a fibrous layer between the approximated parts to provide support and later blended with Glisson and splenic capsule respectively. Due to this layer the spleen and liver remained approximated and when the liver returned to the right hypochondriac region the left lobe elongated producing the beaver tail.

Clinical Correlation: The Beaver tail liver is asymptomatic and discovered accidentally during a CT or MRI scan of the abdomen. Due to liver and spleen's similar echogenicity on ultrasonography and CT the two organs are not easily differentiated that leads to a misdiagnosis of splenic mass, pericapsular or subcapsular hematoma [17]. Anugragha P gave two strategies to distinguish between a BTL and a subcapsular hematoma and is by changing the angle of the transducer to confirm whether there is a difference between the elongated lobe and spleen and other is to look for the variation of portal and hepatic veins using color doppler [3]. The hepatosplenomegaly misdiagnosed by MRI can be differentiated from beaver tail variant as in the former the liver and spleen presents with what is

clinically referred to as kissing sign seen in pathological condition of liver cirrhosis, toxicity, infections, etc. while in beaver tail variant the elongated lobe encircles the spleen completely or partially. [10].

Surgical Significance: Liver transplantations require a complex and varied, multidisciplinary approach involving not only hepatologists and surgeons but also development experts. It is an important and last mode of treatment for patients with chronic liver failure or liver cirrhosis. For liver transplantation the factors assessed for donor and recipient liver are age, weight, gender, alcohol history, neoplastic concerns, infection, graft HLA matching of the donor and recipient, etc. and recently added the liver residual volume [18]. The residual liver volume is the volume of liver left in the donor post-transplant. Research showed that the residual volume of liver if >35% then the donor faced no post-surgical complication while <35% had significant adverse effect on recovery and regeneration of liver and would need intensive care.

B. Yilmaz research of Beaver tail liver found that its volume was 1252mL and percentage of left lobe was 38% making it safer in terms of the residual liver volume in live donor's post-transplant which had a positive effect on healing process and recovery [19]. In the Beaver tail variant after the right lobe is transplanted, the residual elongated left lobe may grow back to normal liver anatomy. Also, in cases of right lobe infection or cirrhosis removing the right lobe to allow the elongated residual left lobe to regenerate, which normally cannot be performed. Only risk is that left lobe cannot be transplanted, resected or repaired as it is fused with the spleen retroperitoneally and doing so would be a difficult procedure leading to massive hemorrhage.

Conclusion

Beaver tail liver is morphological elongated left lobe variant accidentally discovered during a CT or MRI scan and misdiagnosed as a splenic mass, pericapsular or subcapsular hematoma or as hepatosplenomegaly, which can be confirmed with a color doppler scan or by altering the ultrasound transducer angle to see the space between the spleen and liver. Its congenital development is supported by the normal histological appearance, physiological function and no clinical symptoms and could be due to approximation of spleen and liver due to fetal life infection, iron deficiency anemia or growth regulatory molecule defect and with formation of fibrous tissue between the organs to provide support it produces a strong adherence of the organs and subsequent growth forms the Beaver tail shape. It has a larger residual liver volume of 38%, making it suitable for live liver transplants as it benefits the donor with faster regeneration and no added complication.

References

1. Standring S, ed. Gray's Anatomy: The Anatomical Basis of Clinical Practice. Forty-first edition. Elsevier Limited; 2016.
2. Haobam Rajajee Singh, Suganthy Rabi, Study of morphological variations of liver in human, Translational Research in Anatomy, Volume 14, 2019, Pages 1-5 ISSN 2214-854X, https://doi.org/10.1016/j.tria.2018.11.004.
3. Anugragha Palanisamy, Shamila Hussain, Rikil Ambi Sajeev et al. The Beaver Tail Liver – description of a rare variant with a review of its surgical and radiologic implications, 02 February 2024, PREPRINT (Version 1) available at Research Square [https://doi.org/10.21203/rs.3.rs-3893988/v1].
4. Hacking C, Ranchod A, Alhusseiny K, et al. Beaver tail liver. Reference article, Radiopaedia.org (Accessed on 20 Sep 2024) https://doi.org/10.53347/rID-39318.
5. Dunlop DG, Evans RM. Congenital abnormality of the liver initially misdiagnosed as splenic haematoma. J R Soc Med. 1996;89(12):702-704. doi:10.1177/014107689608901212.
6. Hammond LJ. III. Congenital Elongation of the Left Lobe of the Liver. Ann Surg. 1905;41(1):31-35. doi:10.1097/00000658-190501000-00004.
7. Cotelingam JD, Saito R. Hepatolienal fusion: case report of an unusual lesion. Hum Pathol. 1978 Mar;9(2):234-6. doi: 10.1016/s0046-8177(78)80116-6. PMID: 640648.
8. Shabana Sultana. Elongation of the left lobe of liver: a case report. ijamscr [Internet]. 2020 Aug. 4 [cited 2024 Sep. 20];3(2):152-6. Available from: https://doi.org/10.61096/ijamscr.v3.iss2.2015. 152-156.
9. Md Noh MSF, Muhammad SJSS. Beaver in the liver. Pan Afr Med J. 2017 Jun 23;27:138. doi: 10.11604/pamj.2017.27.138.12227]. PMID: 28904667; PMCID: PMC5567963.
10. Sharma, Vinay, and Padamjeet Panchal. "Hiding Beaver Tail Liver: A Rare Anatomical Variant of the Liver." Cureus vol. 16,6 e62665. 19 Jun. 2024, doi:10.7759/cureus.62665.
11. Blakaj, Flamur et al. Hepatolienal fusion combined with Eagle syndrome: A rare case report. (2020).
12. Ghosh A, Amit Kumar Pal. Hepatosplenic fusion in a cadaver - An extremely rare variation. Asian J Med Sci. 2023 Oct. 5 [cited 2024 Sep. 20];14(10):307-10.
13. Sam F, Jacob J, Rabi S. Riedel's Lobe and Beaver Tail Variant: A Cadaveric Case Report. Cureus. 2024;16(2): e54301. Published 2024 Feb 16. doi:10.7759/cureus.54301.
14. Nakamura, Taro et al. "Anatomical variations and surgical strategies in right lobe living donor liver transplantation: lessons from 120 cases." Transplantation vol. 73,12 (2002):

1896-903. doi:10.1097/00007890-200206270-00008.
15. Sadler, T.W. Langman's Medical Embryology, 14th Edition. Lippincott Williams & Wilkins, 2018.
16. Brendolan, Andrea et al. A Pbx1-dependent genetic and transcriptional network regulates spleen ontogeny. Development (Cambridge, England) vol. 132,13 (2005): 3113-26. doi:10.1242/dev.01884.
17. Khanduri, Sachin et al. Beaver Tail Liver: A Hepatic Morphology Variant. Cureus vol. 13,7 e16327. 12 Jul. 2021, doi:10.7759/cureus.16327.
18. Shi ZR, Yan LN, Du CY. Donor safety and remnant liver volume in living donor liver transplantation. World J Gastroenterol 2012; 18(48): 7327-7332 [PMID: 23326141 DOI: 10.3748/wjg.v18.i48.7327].
19. Yilmaz Cankaya B. Can Beaver Tail Liver be the Cause of Preference in Living Liver Transplantation.