A COMPARATIVE ANATOMICAL STUDY OF THE PELVIS IN THE CONTEMPORARY AND MEDIEVAL COW AND ELK

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Abstract. The objective of this work was to research comparing-anatomically the structure, ossification and existence of interischial bone in the cases of the bovine and elk' s pelvis. The both species belong to the order of cloven-hoofed animals, the suborder of ruminants.

Pelvises of four elk cows that originated from the animals of ages three, six, eight and ten years were researched. The results were compared to the ones of 21 cow pelvises studied earlier at the morphology department. For the comparison there partly preserved hip bones from the 15th, 16th and the 17th centuries were also used.

The research methods used were preparation, radiography and biological maceration.

Elk' s pelvis compared to bovine is narrow and stretched out. The external measurements of examined elk pelvises did not differ essentially with age but in the case of bovine the measures increased noticeably.

From the aspect of calving it is interesting that elk's pelvis with the years enlarges just in the caudal part by ischium tubercles drawing away from each other and on account of increase of the angles between ischium plates and between ischium arc.

Between ischiums all examined pelvises had an unpaired bone formation with constant structure and shape – interischial bone. The lower parts of the interischial bone are an unpaired cranial branch situated forward and in the caudal direction follows the body of the bone and a pair of caudal branches that are directed towards ischium arc. On the dorsal surface of the body the crest of interischial bone is situated and on the sides there are collateral surfaces; symphysial eminence and symphysial crest that remain on the ventral surface.

In cattle the interischial bone appears independently from 14 or 15 month to the 6 year and joins then bilaterally with ischium. In the case of the researched elk cows the interischial bone was visible at the age of three and was totally joined at the age of ten.

The elk's pelvis is adapted to the mobile life style of the animal and enables fast running and easy calving.

The life style of the cattle has become sedentary due to a man who has bred it for bigger milk production by increasing considerably udder and body weight. Therefore the pelvis has become more massive and there new bone structures (the pubic spine and the symphysial crest) that were missing in the case of medieval cattle and the elk's pelvis have formed.

Keywords: elk, cow, pelvis, morphology, interischial bone.

DABARTINIŲ IR VIDURAMŽIŲ KARVIŲ IR BRIEDŽIŲ DUBENS KAULO LYGINAMOJI ANATOMIJA

Santrauka. Šio darbo tikslas buvo palyginti dubens anatominę struktūrą, tarpsėdynkaulio (*os interischiadici*) atsiradimo priežastis galvijų ir briedžių dubens kaulų kaulėjimo procese. Abi gyvūnų rūšys priklauso porakanopiams, atrajotojų porūšiui. Buvo tirti 4 briedžių (3, 6, 8 ir 10 m.) ir 21 karvės dubens kaulas. Gauti rezultatai lyginti su anksčiau sukauptais dubens kaulo duomenimis, esančiais Morfologijos katedroje (Estijos žemės ūkio universitetas). Taip pat buvo tiriami XV–XVII amžiaus galvijų dubens kaulai. Tyrime taikyti preparavimo, radiografijos ir maceracijos metodai.

Briedės dubens kaulas palyginti su karvės yra siauras, užpakalinėje dalyje platėjantis. Išoriniai tirtų briedžių dubens kaulų matmenys laikui bėgant iš esmės nesikeitė, tačiau palyginti su galvijų dubens matmenimis jie buvo pastebimai didesni.

Atsivedusios briedės dubens kaulai metams bėgant didėja tik užpakalinėje dalyje prie sėdynkaulio gumburo, pastumdami tolyn vieną nuo kito sėdynkaulio plokšteles ir sėdynkaulio lanką.

11-oje dubens kaulų tarp sėdynkaulių formavosi pastovios struktūros ir formos neporinis kaulas, kurį pavadinome tarpsėdynkauliu (*os interischiadici*). Šį kaulą sudaro neporinė priekinė šaka ir dvi porinės užpakalinės šakos bei ketera.

Karvių tarpsėdynkaulis išryškėja ir suauga nuo 14-15 mėnesių iki 6 metų, o briedžių patelių jis pastebimas nuo 3 metų ir suauga 10 metų.

Raktažodžiai: briedis, galvijas, dubuo, morfologija, tarpsėdynkaulis.

Introduction. The pelvis encircles the birth canal as an osseous ring, and its shape and size are of great significance for normal delivery. Among the domestic animals cows have the largest number of dystocia: 3 to 10 per cent, among the primiparous cows - even 15 to 30 per cent of the births (van Donkerskoed, 1997; Müürsepp et al., 1979). Due to breeding the bovine pelvis has become increasingly unsuitable for delivery, and it is difficult for the fetus to pass through (Duce et al., 2002). An abrupt increase in the body and udder mass has brought about undesirable changes in the pelvic structure that complicate delivery (Jalakas et al. 2000). At the beginning of the 20th century an average Estonian cow weighed 440 kg, and the average milk production reached 2311 kg. In the

year 2002 the body mass of a cow was between 650 and 700 kg, and the milk production reached between 8000 and 9000 kg on the farms that provided material for our study.

As the elk also belongs to the order of Artiodactyla, the suborder of ruminants, it is suitable for comparison with the bovine animal.

The present study continues a series of studies on the suspensory apparatus of the udder and pelvic structure of the Estonian Holstein Breed (EHF) cows that have been carried out in recent years at the Departments of Therapy and Morphology at the Estonian Agricultural University. The aims of this study were to compare the pelvic structure and ossification in the elk, medieval cow, and contemporary high-production cows, and to determine the existence of the interischial bone.

Material and Methods. We studied the pelvises of four female elks originating from three-, six-, eight-, and ten-year-old animals. The age of the animals was roughly determined on the basis of teeth.

The study material of cows came from two dairy farms of EHF cows – Estonia Ltd and Põlva Agricultural Ltd. In Estonia Ltd 1821 EHF cows yielded 8439 kg milk per cow in 2002; in the Põlva Agricultural Ltd. the annual milk production per cow reached 9130 kg (Pentjärv et al., 2003: Estonian Animal Recording Yearbook 2002,). Twenty-one pelvises of cows of various ages were studied.

For comparison we used relatively well-preserved hip bones of two adult cows dating from the 15th, 16th and 17th century.

The hip bones were studied by means of preparation with regard to the shape and size of the apophyses and the attached tendons. For pelvimetry the soft tissues were completely removed from the pelvis. The measurements were carried out with the help of calipers, ruler, compasses, and a protractor. We measured the pelvic indicators as a whole and all the bones separately. Biological maceration was applied in order to remove the inter-ostial cartilaginous joints. The maceration took place in a thermostat at 38–40 °C in water in a container closed by a lid. During the period of three weeks the soft tissues became separated from the bones, which enabled us to obtain a better picture of the symphysial surfaces, apophyses, and the interischial bone.

In order to X-ray the pelvic symphysis, the wings of the ilia together with the sacrum were removed by cutting through the bodies of the ilia. The pelvic floors were X-rayed in the dorsoventral direction before the maceration. The acetabula were X-rayed after the maceration.

Research findings and discussion. The osseous pelvic floor of the *contemporary high-production cow* has become a U-shaped concavity. It rises so abruptly starting with the caudal edge of the obturator foramina that forms a 40° angle with regard to the horizontal plane. In the adult cow the hip bones are joined osseously, and the pelvic symphysis is ventrally reinforced by the symphysial crest. Therefore, the pelvic cavity can be widened at the time of delivery only by relaxing the sacroiliac joint and the broad sacrosciatic ligament (Jalakas and Saks, 2001). The lateral osseous walls of the pelvic cavity consist of the bodies of the ilia, ischial plates, and the high and broad ischial spines. As the latter take a slightly inside direction, they form the narrowest spot of the birth canal. The bovine pubis has a dorsal pubic tubercle that diminishes with age and almost disappears by the third delivery (Roberts, 1986).

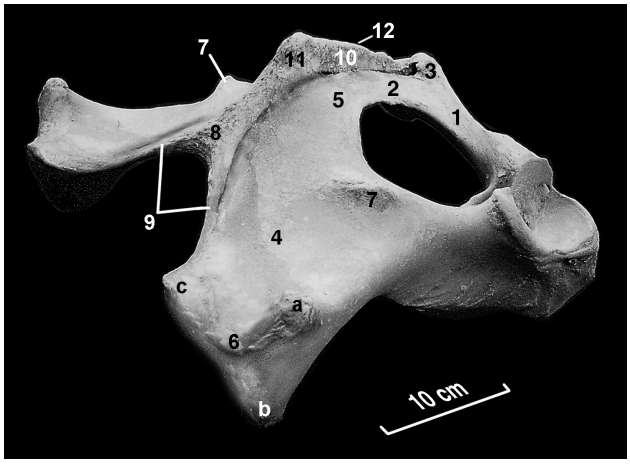

Figure 1. **The ventrolateral view of the pelvic floor of the5 years and 7 month old cow**
1 – ramus cranialis ossis pubis, 2 – ramus caudalis ossis pubis, 3 – tuberculum ventrale ossis pubis, 4 – tabula ossis ischii, 5 – ramus ossis ischii, 6 – tuber ischiadicum, a – tuberositas lateralis, b – tuberositas cranialis, c – tuberositas caudalis, 7 – eminentia ossis ischii, 8 – corpus ossis interischiadici, 9 – rami caudales ossis interischiadici, 10 – ramus cranialis ossis interischiadici, 11 – eminentia symphysialis ossis interischiadici, 12 – crista symphysialis ossis interischiadici

All the studied pelvises had an unpaired interischial bone (*os interischiadicum*) between the ischia (Fig. 1). The more important parts of the latter include the caudally positioned body that is 80–120 mm in length in an adult cow, paired caudal branches (70–110 mm in length), unpaired cranial branch (70–90 mm in length) with a crest between the lateral surfaces separating the hip bone in the ischial symphysis, and the ventrally located symphysial eminence and the symphysial crest (Jalakas and Saks, 2002). The length of the body of the interischial bone almost does not decrease with age, but the cranial branch lengthens remarkably in the cranial direction along the pelvic symphysis (being twice longer in a multiparous cow aged from 5 to 6 years than in a primiparous cow at the age of three). It could be explained by the fact that the symphysial tendon as an important part of the suspensory apparatus of the udder becomes attached to the symphysial crest, which is formed on the ventral surface of the cranial branch and the hip bones grow together. The symphysial eminence increases to a lesser degree. In most cows its height ranged from 20 to 30 mm.

The *medieval* bovine bones reveal that at that time cows had a narrower, more stretched out and U-shaped pelvis. The pelvis floor was narrowed and the top was widened. The bones were also smaller and thinner, the majority of measurements being smaller than in the contemporary cow. The pelvic inlet had an oval shape. The greatest diameter of the pelvic inlet between the tubercles of the psoas minor muscle was twice as long as the cranioventral transverse diameter that joins the

iliopubic eminences. The pelvic cavity was narrower in the cranial part and widened slightly in the caudal direction. Also, the angle between the ischial plates points to this, which was 130° in the medieval cow but on average 116° in the contemporary cow. The pelvic floor took an almost straight course, beginning to rise in the caudal direction at the caudal edges of the obturator foramina. The rise was flat in the direction of the ischial arch. The dorsal pubic tubercle was located as a blunt crest in the dorsocranial edge of the pubis. The iliopubic eminence was also crest-shaped and protrusive. There was a groove from 5 to 10 mm in width in the anterior edge of the cranial branch of the pubis. The obturator foramen was large and oval, and its axis was craniolaterally positioned. The symphysial crest was weakly developed; the body of the interischial bone was short, its cranial branch reaching only the caudal third of the obturator foramen. From there onwards one could observe a long non-ossified slit in the median plane up to the joining point of the cranial and caudal branches of the pubis. The medieval adult cow had also the interischial bone, the cranial branch of which was twice as short as the body of the bone. The greater and the lesser sciatic notches were extremely low. Also, the ischial spine was low and thin and with little osseus crest for attaching the muscles. The ischial spine rose vertically but not inwards as in contemporary cows. The acetabula was low.

The symphysial eminences were not preserved completely. However, the existing material enabled us to conclude that thy were rather low. Unfortunately, the caudal parts of the ischium with ischial tubers were not preserved.

The pelvis of the *female elk* shares some similar features with the pelvis of the medieval cow. Here the cranial pelvic inlet is also evenly oval, and to the best of our knowledge it does not change considerably with aging. The pelvic floor is usually flat; its length is close to that of the medieval cow. There is also a slight rise in the caudal part. The floor is U-shaped caudally from the obturator foramina, whereas in older individuals it is wider. The pelvic floor is the deepest above the cranial branch of the interischial bone. In the pelvic symphysis there is a slit-like space that has not grown together at the joining place of the caudal branch of the pubis and the branch of the ischium. Its length depends on the age of the animal, being 48 mm in a three-year-old cows and 23 mm in a ten-year-old ones (Fig. 2).

Similarly to the hip bones of the medieval cow, the elk also has iliopubic eminences in the anterior edge of the pubis connected by the groove where *tendo prepubicus* is located. The dorsal pubic tubercle occurs in the pelvis of a three-year-old female elk as a crest on the median line and protrudes cranially on the pubic pecten as well. It has become lowered and smoothed in the pelvis of a six-year-old animal, but the ventral pubic tubercle has retained its size. The groove in the pubic pecten develops with ageing when the dorsal pubic tubercle is lowered, and the cranial part of the pecten recedes.

The coxal tubers resemble those of the horse, being shaped like an oblong rhombus where the higher crest courses between two angles. The tubers are craniolaterally strongly stretched out, thus providing a stretched-out appearance to the entire pelvis. The coxal tuber ranges between 72–84 mm in length. The crest of the ilium is thickened in the medial angle and forms the sacral tuber that consists of a single part like in the bovine animal. The sacral tubers are located lower than the median sacral crest.

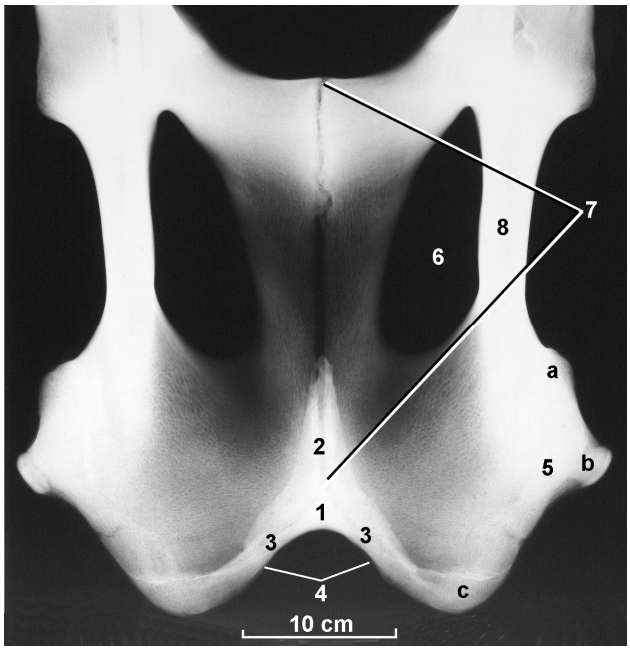

Figure 2. **The radiograph of the pelvic floor of the 6 years old female elk**
1 – corpus ossis interischiadici, 2 – ramus cranialis ossis interischiadici, 3 – rami caudales ossis interischiadici, 4 – arcus ischiadicus, 5 – tuber ischiadicum, a – tuberositas cranialis, b – tuberositas lateralis, c – tuberositas caudalis, 6 – foramen obturatum, 7 – symphysis pelvina, 8 – corpus ossis ischii

The size of the obturator foramina is comparable to that of the medieval cow. The direction is also craniolateral; however, the elk has a blunt notch in the cranial end 15 mm in diameter, which becomes more pronounced with age (Fig. 3).

The pelvic cavity narrows dorsally, which can be seen especially well above the ischial spines. The ischial spines are low; there are little osseous crests on their lateral sides for attaching the muscles.

The greater and lesser sciatic notches are lower than in the cow. However, in the elk the lesser sciatic notch is deeper than the greater one (in the cow it is the other way round), and it also has a much more acute angle. The narrowest spot in the pelvises of the elk and the medieval cow can be found in the transverse plane that passes through the middle of the obturator foramina, where the ischial bodies are bent towards the pelvic cavity. By contrast, in the contemporary cow the narrowest spot lies between the ischial spines.

Also, in elks the distance between the acetabula is almost the same as in medieval cows between 130 and 140 mm, whereas in contemporary cows it is between 190 and 210 mm.

The ischial arch has an acute angle. The ischial plate is rather broad because the lesser sciatic notch is low. In the elk the ischial tuber is positioned on the same level as

the lateral edge of the obturator foramina. In the cow, however, it is positioned considerably higher. The pelvic-side surface of the ischial plate is not concave, but the plate takes an almost straight course in the lateral direction. In the medieval adult cow the ischial plates form an obtuse angle whereas in younger female elks they are positioned at an acute angle of 70°–80°. With age the acute angle changes into an obtuse angle, but it is still much smaller than that in the contemporary cow. In the elk the ischial tuber is relatively smooth. Similarly to the cow, one can distinguish between the cranial, lateral, and caudal tuberosities. According to our data, the distance between the cranial and caudal tuberosities of the ischial tuber was between 113 and 126 mm. The caudal tuberosety is barely noticeable and has shifted backwards to a considerable extent. For this reason, the dorsal edge of the ischial plate merges rather smoothly into the ischial arch. The caudal edge of the broad sacrosciatic ligament is attached also to the first coccygeal vertebra. In the cow, however, it is attached to the last sacral vertebra.

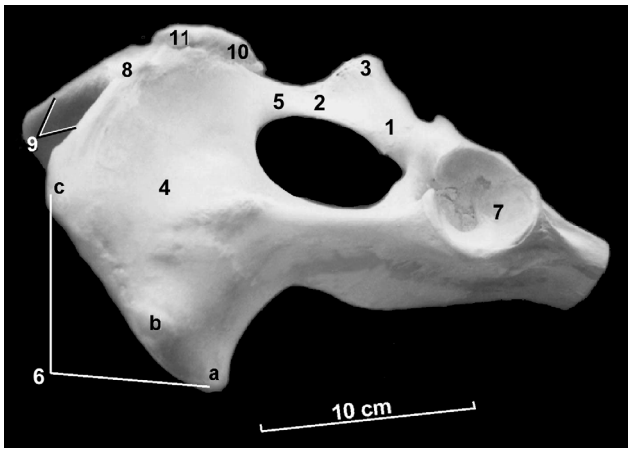

Figure 3. **The ventrolateral view of the pelvic floor of the 10 years old female elk**
1 – ramus cranialis ossis pubis, 2 – ramus caudalis ossis pubis, 3 – tuberculum ventrale ossis pubis, 4 – tabula ossis ischii, 5 – ramus ossis ischii, 6 – tuber ischiadicum, a – tuberositas cranialis, b – tuberositas lateralis, c – tuberositas caudalis, 7 – acetabulum, 8 – corpus ossis interischiadici, 9 – rami caudales ossis interischiadici, 10 – ramus cranialis ossis interischiadici, 11 – eminentia symphysialis ossis interischiadici

The pelvic cavity of the elk is wider due to the kyphosis (22 to 31 mm), which is formed above the last sacral vertebrae, whereas the pelvic surface of the bovine sacrum is rather straight.

All the studied pelvises of female elks had the interischial bone (Fig. 4). The length of the body of the interischial bone did not change considerably with age. Its average length in the elk was only 30 mm. The length of the cranial branch of the interischial bone increases with age. In a three-year-old animal it is 42 mm and in a ten-year-old - 54 mm. The difference between the length of the body and the branch is only 10–22 mm. According to our data, in the elk the symphysial eminence is low, being from 16 to 20 mm, like in the medieval cow.

The same conclusions can be drawn by studying the X-ray images of the pelvic floors of the elk. The pelvic symphysis of a three year old female elk had not ossified as yet – one could clearly see a slit-like space between the pubes. There was no thorn-like bone structure of the pubis. One could see the body of the interischial bone as well as the cranial and two caudal branches.

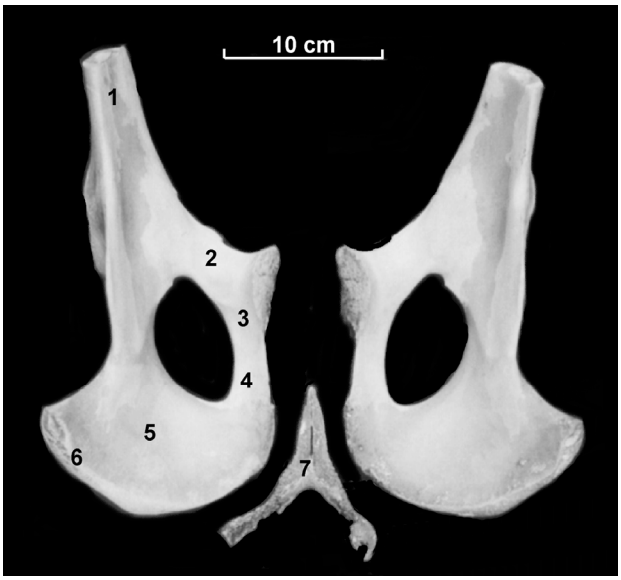

Figure 4. **The dorssal view of the hip bones and interischial bone of the 3 years old female elk**
1 – corpus ossis ilii, 2 – ramus cranialis ossis pubis, 3 – ramus caudalis ossiis pubis, 4 – ramus ossis ischii, 5 – tabula ossis ischii, 6 – tuber ischiadicum, 7 – os interischiadicum

In comparison with a three year old elk, in an eight-year-old elk the cranial branch of the interischial bone is somewhat longer, and accordingly the slit that is located in the symphysis is shorter. The latter has retained its width only between the caudal branches of the pubes, being, however, already much narrower in the cranial part.

In a ten-year-old elk the caudal branches of the interischial bone have become completely attached to the ischial plate. The hip bones are still separated only in the middle part of the symphysis.

The X-ray image of the acetabula of a young female cow shows two ossified belts from 1.5 to 2 mm in width between the cranial branch of the pubis and the body of the ilium located laterally from the iliopubic eminence in the edge of the acetabulum. Their joint has a V-shape in direction to the acetabular fossa.

At a young age the human and the bovine animal have an iliopubic synchondrosis that becomes ossified in adults. It is likely that a similar process may take place in the acetabulum of the elk. However, further research of this problem is needed.

Conclusions. All the pelvises had the interischial bone between the ischia. It occurred as a separate bone in cows starting with the age of 14 and 15 months until the age of six, and then became attached to the ischia. In the studied female elks the bone could be distinguished in a three year old animal, but it had become completely attached to the ischium in a ten year old animal. It is characteristic to elks that the bone has a short body and a

slightly longer cranial branch. However, both of them were shorter than in the cow. It is possible that the interischial bone may be visible as a bone in an even younger animal, but we did not have any suitable material.

The diameter of the cranial branch of the pubis above the ventral pubic tubercle was almost the same in all the studied animals. The youngest animals had a crest-shaped dorsal pubic tubercle. In older animals it had degenerated; the ventral tubercle, on the other hand, had not decreased.

In all the studied animals the longitudinal axis of the obturator foramen was craniolateral. The elk had a blunt notch in the cranial edge of the obturator foramen, which helps to make a distinction between the pelvises of the bovine animal and the elk.

The pelvic floor of the medieval cow was similar to that of the elk with regard to its proportions. It was U-shaped, it widened towards the dorsal and caudal directions, the distance between the acetabula and the diameter of the acetabulum are also similar. On the other hand, the shapes of the pubis and ilium resembled the contemporary cow.

The hip bones of both the medieval cow and the elk had a groove in the anterior edge of the pubic pecten. The contemporary cow had developed a pubic spine in the cranial edge of the pubic symphysis. The narrowest spot of the pelvic cavity of the medieval cow and the female elk were the distance between the ischial bodies in the transverse plane passing through the middle of the obturator foramina. In the contemporary adult cow the narrowest spot of the pelvic cavity was located between the ischial crests.

The kyphosis on the sacrum of elks ranged between 20 and 30 mm, which possibly helps to compensate the narrowness of the pelvis during the delivery. The pelvic surface of the bovine sacrum had a more or less straight course.

The ischial plates of the elk formed a more acute angle than those in the bovine pelvis, that is, the pelvis was more U-shaped than in the cow.

By comparison with the cow the pelvis of the elk was narrow and stretched out – its length from the hip tuber to the ischial tuber was longer than the width between the hip tubers. In the cow the width was larger than the length.

The pelvis of the elk is well adjusted to its mobile lifestyle, allowing quick movement and easy delivery.

Owing to breeding, the pelvis of the contemporary cow is more massive than that in the medieval animal. Also, it has developed new osseous structures, and the pelvis has become less suitable for delivery.

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