THE BREATHING – INDUCED MOVEMENT OF THE PANCREAS

A sonographic basic research from Irmtraud Lenius in cooperation

with Dr. Günther Nics, radiologist.

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2006, Hollabrunn - Austria

ABSTRACT:

In osteopathic literature the pancreas is considered to be a retroperitoneal fixed organ. Nevertheless there are different theories how this organ behaves at increased breathing. With the assistance of the radiologist Dr. Günter Nics the movement of the pancreas becomes measurable and documentable.

With ultrasound it is very easy to localize the pancreas. The changes of position of this gland at forced breathing explain the amplitude of the movements in cranio-caudal direction as well as in horizontal position lying on one's back, on one's left and right side. The pancreas declines at maximum inhalation up to 64,5 mm.

With the horizontal view there are different movements noticed. Among men the tail of pancreas approaches the vertebrarium at inhalation, whereas among women, who have not given birth yet, you can notice a removal of the tail from the vertebrarium. Among all the examined persons these horizontal movements (on the average 6,2 mm and –7,7 mm on one’s back, 8,2 mm and –8,2 mm in left half-declination and 6,7 mm and –4,4 mm in right side position) are notably smaller than the cranio-caudal movements.

The breathing's influence on the abdominal organs and especially on the pancreas is not to be underrated. But also the position of the patient has a noticeable effect on the position and form of the pancreas.

DECLARATION:

Ich versichere, dass ich die Masterthesis ohne fremde Hilfe selbständig verfasst und nur die angegebenen Quellen benutzt habe. Wörtlich oder dem Sinn nach aus anderen Werken entnommene Stellen sind unter Angabe der Quellen kenntlich gemacht.

I assure, that I have written this mastertheses independently and without outside help. I just used the stated references. Quotations and analogous passages, quoted from outside literature are marked and the sources are specified.

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INTRODUCTION

Osteopathy is concerned with the mobility of all body structures. Biomechanics of the musculoskeletal system has often been subject matter of studies. Visceral osteopathy, which is the latest field of knowledge in osteopathy, contains a lot of unanswered questions and as a student one often gets contradictory answers. Do the movements of the abdominal organs have a regulated direction and how are directions determined? Do all abdominal organs move or are there some fixed regions? Particularly concerning the pancreas I got very conflicting answers to these questions in osteopathic technical literature as well as among experienced osteopaths.

Eric Hebgen (2004) relies in his book *"Viszeralosteopathie – Grundlagen und Techniken"* on Barral's theory of visceral osteopathy. Hebgen also dedicates a whole chapter of his book to the fascial treatment of organs according to G. Finet and C. Williame (2000).

The fascial connective tissue of the body is a continuum, which reacts as an entity to all disturbing factors. A conglutination at depth, e.g. due to a preceding operation, can be noticed at the outside and affect the mobility and motility of the organs.

> *"Das Diaphragma ist der Motor der faszialen Bewegung der abdominellen Organe. Die Verlagerung der Organe nach kaudal in der Inspiration beinhaltet auch eine fasziale Bewegung nach kaudal im Abdomen. Neben dieser Kaudalbewegung führen die einzelnen Organfaszien noch zusätzlich begleitende Rotationen aus."*
>
> *(**Hebgen 2004**, page 6)*

"The diaphragm is the motor of the fascial movement of abdominal organs. A displacement of the organs towards caudal while inspiration implies also a fascial movement towards caudal in the abdomen. In addition to this caudal movement the organ fascias carry out collateral rotations."

*(**Hebgen 2004**, page 6, translated by Walchshofer)*

In his chapter *pancreas* Hebgen states that the pancreas has no own mobility due to its fascial anchoring.

As Barral (1983) he describes motility as a wave, which is, in expiration, sensible from the caput pancreaticus right up to the cauda.

Hebgen suggests two ways of treatment: on the one hand a treatment of the pancreas motility according to Barral (1983) and on the other hand a fascial technique according to Finet and Williame (2000) whereby the cranio-caudal mobility of the pancreas shall be improved by means of respiration.

Circulatory techniques according to Kuchera (1994) and reflex point treatment according to Chapman (see Weber and Wiese: Lehrbuch der Orthobionomy. Sonntag Verlag. Stuttgart 2001) round the therapeutic approach off.

In his *"Lehrbuch der viszeralen Osteopathie – Peritoneale Organe"* **Helsmoortel (2002)** places the autonomy of the organs in the centre of his reflections. Although the retroperitoneal pancreas is not particularly treated in his book I would like to point out some of Helsmoortel's essential thoughts. In the preface Frank Roels, D.O., co-director of the SKOM (Schule für klassische osteopathische Medizin), writes:

„Das manuelle Behandeln der abdominalen Organe mit ihren verschiedenen Bewegungsqualitäten ist inzwischen ein wesentlicher

Bestandteil der therapeutischen Möglichkeiten der Osteopathie geworden......Sie [die Autoren Helsmoortel, Hirth und Wührl, Anm. d. Verf.] haben die traditionelle Basisidee und Ausführung der viszeralen Osteopathie aktualisiert und mit wissenschaftlichen Grundlagen unterfüttert. Die Verknüpfung von Osteopathie und konventioneller medizinischer Wissenschaft ist originell und hilfreich.“

*(**Helsmoortel 2002**)*

“Manual treatment of abdominal organs with their different qualities of movement has become an important component of the therapeutic possibilities in osteopathy. […] They [the authors Helsmoortel, Hirth and Wühr, author’s note] have updated the traditional basic idea and the realization of visceralosteoptahy and have furthermore undermined them with scientific bases. The conjunction of osteopathy with conventional medical science is original and helpful.”

*(**Helsmoortel 2002**, translated by Walchshofer)*

Helsmoortel particularly refers to the intestinal tube and resultant organs.

„...viszerale Strukturen vereinen alle drei Gewebe [Entoderm=Mukosa, Mesoderm=glatte Muskulatur und das bindegewebige Skelett, Ektoderm=neurologisches Gewebe; Anm. d. Verf.] in sich. Diese wirken zusammen und können sich gegenseitig unterstützen. Alle Gewebe der Viszera tragen zur autonomen antigravitatorischen Funktion bei. Sie befähigen das Organ, gegen den Einfluß der Schwerkraft und aus eigener Kraft an Ort und Stelle zu bleiben. Dies garantiert eine optimale Versorgung und Funktion...“

*(**Helsmoortel 2002**, page 3)*

“… visceral structures unite all three tissues [entoderm = mucosa, mesoderm = smooth musculature and connective tissue, ectoderm =

neurological tissue, author's note]. They all collaborate and back each other. All tissues of the viscera contribute to the autonomic anti-gravitatory function. They enable the organ to stay, against the force of gravitation, self-governed in place. This guarantees an optimum supply and function."

*(**Helsmoortel 2002**, page 3, translated by Walchshofer)*

Furthermore he states:

„.....bei der embryologischen Entwicklung hat das Organ seine eigene Position gefunden, und seine Autonomie erlaubt ihm, diese zu erhalten. Die räumliche Bewegung gehört in unserem Konzept nicht zum Ausdruck der eigenen Funktion der Organe. Normalerweise besteht eine positionserhaltende Kraft, wohingegen die räumliche Bewegung des Organs Ausdruck eines Funktionsverlusts (Ptose) oder einer externen kompensatorischen Kraft ist."

*(**Helsmoortel 2002**, page 4)*

"… during the development of the embryo the organ finds its own position and its autonomy permits it to preserve it. According to our concept, the spatial movement does not express the organ's proper function. Normally there is a positions conserving force, whereas the spatial movement of the organs is the expression of a loss of function (ptosis) or an external compensatory force."

*(**Helsmoortel 2002**, page 4, translated by Walchshofer)*

Helsmoortel becomes even clearer:

"Eine räumliche Bewegung der Viszera ist physiologisch (mit Ausnahme der Lungen bei der Atmung) nicht notwendig. Bei einer

Ruheatmung von 0,5 l wird das Massezentrum der abdominalen Organe und der Viszera nicht bewegt. Es kommt lediglich zu einer Kompression des abdominalen Inhalts. [...] wird geatmet um die Organe zu mobilisieren, liegt eine Kompensation vor..."

*(**Helsmoortel 2002**, page 5)*

"A spatial movement of the viscera is physiologically (except for the lungs while respiration) not necessary. At quiet respiration of 0,5 l the center of the abdominal organs and of the viscera (MASSEZENTRUM) is not moved. It only comes to a compression of the abdominal content. […] If one breathes to mobilize the organs there is compensation."

*(**Helsmoortel 2002**, page 5, translated by Walchshofer)*

In chapter *Duodenum, Fixations and Conjunctions* (page 255) he describes a fibrous ligament, which ties the pancreas to the aorta. As a relic of the duodenal mesos it contains neurovascular structures by means of which information about the changes of positions of the pancreas are passed on to ganglion coeliacum.

Barral emphasized already in 1983 in his book "*manipulations visceralses 1*" the importance of the mobility of the inner organs. He has coined the expression 'visceral articulation'. Visceral organs are coated with serous skins, which are, according to Barral, the meninges, the pleura, the peritoneum and the pericardium.

To make the vacillation of volume and the displacement of organs possible there is a cleft between the tissue around the organ (visceral layer) on the one side and the layer that coats abdominal cavity (parietal layer) on the other side. This cleft is filled with a serous fluid, which serves as lubricant but also has an important function for the immune system. As a precondition for the preservation of the position of visceral organs Barral mentions the turgor and the pressure in the peritoneal cavity. Turgor is the quality of organs to unfold, depending on elasticity, vascular system and content of the organ. The peritoneal cavity's pressure is the sum of intravisceral pressure and the pressure between the organs.

> *„Sowohl Turgor als auch intrakavitärer Druck tragen dazu bei, dass eine relativ homogene Eingeweidesäule zustande kommt, auf die sich das Zwerchfell bei der Einatmung absenkt.“*
>
> *(**Barral 2002**, volume one, page 14)*

> *„Both turgor and peritoneal cavity's pressure contribute a relatively homogenous visceral column on which the diaphragm falls down during inhalation.”*
>
> *(**Barral 2002**, volume 1, page 14, translated by Walchshofer)*

In volume two of his “*Lehrbuch der viszeralen Osteopathie”* Barral dedicates a whole chapter to the pancreas and the spleen (page 125-140). After anatomy, physiology and pathology he mentions the osteopathic-diagnostic approach by means of the ecoute-test. As treatment techniques he suggests above all induction techniques and, because of the violability of the pancreas, the treatment of adjoining organs. About the mobility of the pancreas he writes:

> *„...Während Pankreaskopf und –körper ziemlich lagestabil sind, ist der Pankreasschwanz beweglicher und so tief im Körperinneren gelegen, dass er schwierig palpiert und unmöglich von der Umgebung abgegrenzt werden kann.“*
>
> *(**Barral 2002**, volume two, page 126)*

"…While pancreatic head and body are relatively stable in position, the pancreatic tail is more flexible and located so deep inside the body that it becomes quite difficult palpate and impossible delimitate it."

*(**Barral 2002**, volume two, page 126,translated by Walchshofer)*

In **Ligner's** class **(2004)** we heared about the stabilizing element of the abdomen in connection with the tail of the pancreas and the hilius of spleen.

Kivisaari et al (1982) made examinations on the pancreas' mobility with computed tomography. They discovered cranio-caudal movements of the pancreatic body in relation to the 1^{st} or 2^{nd} lumbar vertebrae up to 6,2 cm and movements of the tail of pancreas up to 8,8 cm. Following clinical endoscopic retrograde pancreatography in 28 patients the upper abdomen was radiographed during normal inspiration and expiration. The mobility of the contrast filled pancreatic duct was measured at three points (head, body, tail) in relation to the first or second lumbar vertebra.

The most mobile part of the pancreas is the tail. The limits of respiratory movement of the normal pancreatic tail were from 0.5 to 8.8 cm. The normal pancreatic body moved from 0.9 to 6.2 cm, and even the pancreatic head moved from 0.9 to 5.6 cm. Chronic pancreatitis did not appear to fix the organ. But the pancreas with cancer in the head seemed to be less mobile.

The craniocaudal mobility of the pancreas is remarkable as compared to the craniocaudal width of the organ. As the craniocaudal excursions of the pancreatic tail may reach 9 cm, which is three times the width of the tail, it is easy to understand why the tail may not be visible in pancreatic computed tomography if respiration is hardly controlled.

For successful pancreatic CT it is important to have the respiratory phase as consistent as possible throughout the whole investigation.

Kivisaari (1982) refrains from a statement about the patients' position and does not write anything about the influence of the patients' position on the pancreas. Also other mobility directions of the pancreas are not mentioned. Kivisaari works on adequate respiration, which makes it rather impossible to combine his statements and results with those of Helsmoortel who works on quiet respiration. It does not become clear if Helsmoortel's (2002) quiet respiration (1/2 litre) corresponds with Kivisaari's (1982) adequate respiration.

The results of **Bryan et al (1984)** with ultrasound are a somewhat different. Respiratory movement of the pancreas from full inspiration to full expiration was measured in the plane of the superior mesenteric artery in supine, prone and decubitus positions.

36 subjects, including patients without known pancreatic disease and normal volunteers were examined (3,5-MHz linear-array real time scanner).

The maximum excursion from full inspiration to full expiration was measured in the plane of the superior mesenteric artery in the supine and right decubitus positions. The linear-array transducer was placed on the skin in the sagittal plane and movement of the pancreas was recorded from full inspiration to full expiration without moving the transducer. Excursion was estimated by obtaining freeze-frame images at the extremes of respiration and measuring the distance from the superior margin of the pancreas to the edge of the scan frame. Patients were examined in the prone position on an automated water-path scanner.

In order to correlate the ultrasonic finding of pancreatic movement with the anatomic attachments of the pancreas, particulary to the adjacent vessels, two fresh cadaver pancreases were dissected at autopsy.

Respiratory movements of the pancreas varied from 0 to 3,5 cm.

The pancreas moved averagely from 1,8 cm in supine position, 1,9 cm in the prone position to 2,2 cm in the lateral decubitus position. The pancreas was found in some instances to move considerably in relation to the superior mesenteric artery, sliding up and down along the artery as much as 3 cm. In contrast to the artery, the superior mesenteric vein moves with the pancreas during respiration. This is presumably related to the fact that the superior mesenteric artery is anchored to the aorta, whereas the superior mesenteric vein is attached to the splenic and portal veins, both of which can move with the pancreas.

Dissection of two normal pancreases at autopsy showed that the pancreas is attached to the superior mesenteric and splenic arteries by relatively long bands of fibrous stroma, which allow a considerable degree of movement of the pancreas relative to the arteries. The splenic and superior mesenteric veins are much more closely attached to the pancreas. It was possible to move the pancreas 2-3 cm along the superior mesenteric artery while anchoring the artery. The relatively long bands of fibrous stroma, which connect the artery and the gland act, like ‘mooring ropes’ which allow a certain amount of relative excursion between the two.

The extent to which the pancreas moves is variable. Sometimes the liver is seen to slide over the pancreas an inspiration, whereas at other times the pancreas is displaced inferiorly by the liver. The gastric antrum and pylorus may also be displaced to a greater or lesser extent than the pancreas. The left lobe of the liver itself is sometimes seen to change shape between full inspiration and full expiration. The proximal portion of the pancreas is largely displaced by the liver, which in turn is displaced by the diaphragm. The tail of the pancreas is enclosed in folds of the lienorenal ligament, and thus, movement of the distal portion of the gland is effected via the left kidney and spleen.

The observation that the gland moves more in the decubitus position than in either the supine or the prone position was somewhat surprising, as they have found decubitus scanning to be frequently of benefit in outlining the head of the pancreas on CT scanning. They had thought that the improved visualization by CT in the decubitus position might be due to diminished respiratory excursion, but this obviously is not the case. The advantage of decubitus CT scanning of the pancreatic head is probably due more to improved outlining of the duodenum by ingested contrast material than to any immobilizing effect of the decubitus position.

Breath-holding during shallow respiration is probably the optimal condition for performance of both static B scan and CT examinations.

Bryan et al. (1984) describe, as Kivisaari (1982) does, only a cranio-caudal movement of the pancreas. Yet they work with maximum inspiration and maximum expiration and three different positions of their patients. Anatomical conditions are outlined well and explain the pancreas' mode of movement. Also other individual influences of surrounding organs are mentioned. According to latest insights the use of a linear-array transducer is not ideal because of a higher risk of artefacts (which have an influence on the interpretative accuracy of the scan) than when using a curved-array transducer.

In a body, whose bones have an inherent mobility (**Baker**, 1971; **Fryman**, 1971), it is not possible to fix an area like the retroperitoneum. My ultrasound study should give osteopaths a clear insight into the movements of the pancreas. Furthermore I would like to find out, if there is, besides the cranio-caudal, also a horizontal movement. And finally I would like to show that there is a relation between the position of the patients and the pancreas' extension of movement. The aim of my thesis is to bring in some light into this, of osteopathy unexplored part of this organ.

BASICS

1) Physiology of the organ's movements

(cp. Helsmoortel, 2002)

There are 3 different types of movements of the inner organs:

1.1) Motricity

Motricity describes the passive nature of the organs caused by activities of the musculosceletal system and the movements of the body in space connected to the muscoskeletal system. For example, when sitting the small and the large intestine are getting compressed and this can also have a negative influence on the peristaltic movement.

1.2) Mobility

Helsmoortel (2002) looks at the mobility of the inner organs from every angle. With the mobilisation, starting from the diaphragm of the organ, he differentiates breathing in rest from forced breathing.

At breathing in rest there is a compression of the organs of the abdomen but without any movements in space. He speaks of an amazing and stress-regulating effect of the breathing in rest on the organ. At forced breathing the diaphragm raises its motor activity. In his theoretical draft he distinguishes the abdominal organs at increased breathing into three phases of mobilisation (Ill.1.a-c)

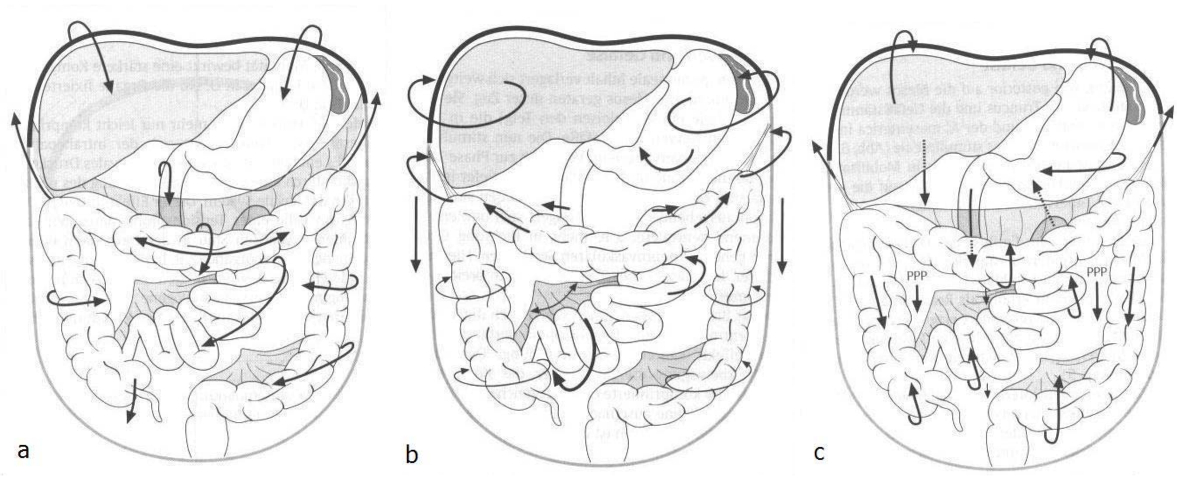


Illustration 1 a-c: Overview of the three-dimensional movements of the abdominal organs in the 3 phases of mobilisation (according to **Helsmoortel**, 2002)

In *phase one* (ill. 1a) the diaphragm falls and rotates around a frontal axis towards anterior. Because of this impulse the organs, which lie below the diaphragm, rotate towards anterior. Like this the organs, which are situated above the mescolon transversum, show the largest amplitude of movement.

In the *second phase* (ill. 1b) the diaphragm keeps sinking, takes the peritoneal content for resistance and revolves together with the ribs towards lateral. The peritoneal structures follow this external rotation too, especially those parts lying lateral.

In the *third phase* (ill. 1c) the diaphragm rotates towards posterior. This happens because the strong contraction of the crura makes the diaphragm sink posterior lower than anterior. In this phase the pars sternalis of the diaphragm lifts the sternum towards anterior and posterior. During this period the viscera lying posterior lower more than the anterior structures.

Helsmoortel accentuates that inside the peritoneum the organs have links of different strength with the parietal system (peritoneum/diaphragm). He constitutes the head of the pancreas, as secondary retroperitoneal structure, as strongly fixed. He characterises the tail of pancreas as mobile but not disconnected because of mesodermal connections to the peritoneum parietal.

1.3) Motility

We talk about motility in connection with movements in growth in embryonic time. **Helsmoortel** (2002) distinguishes between an intrinsic and an extrinsic motility. While the extrinsic motility can be traced to the tonicity and activity of the providing blood vessels, the driving force for the intrinsic motility is inside the organ. Because of the shaping growth of the organs, which allows the development of a three-dimensional elasticity inside the tissue, there evolves an inner torsion, which can be found in the two main directions at a time. These organ-specific directions express in the inner a dynamics, which is periodic and two-phased. Due to this inner dynamics the organs move according to the shaping growth not in space but in themselves. These intrinsic movements of the organs can be explained by the movement-memory, which is saved in each cell of the organ and trained hands of an osteopath are able to notice these movements.

2) Anatomy and Physiology

(cp. Netter, 2000; Sobotta, 2000; Faller, 2004)

I would like to elaborate on the anatomic circumstances because it is necessary to have a lot of three-dimensional imaginations to understand the ultrasound imagines.
The pancreas is an exocrine and an endocrine gland. It is 14-20cm long, weights 70-80g and is intrinsically soft. The pancreatic juice is alkaline, has a high percentage of bicarbonate and neutralizes the acidic milieu of the duodenum.

2.1.) Anatomy

(cp. **Netter**, 2000 ; **Sobotta**, 2000)

We make a distinction between the head, which is embedded in the duodenum (c*aput pancreatis*) with the uncinate process of the pancreas, the body (*corpus pancreatis*), which crosses the spine and the aorta, and the tail (*cauda pancreatis*), which reaches to the hilus of spleen (Ill.2).

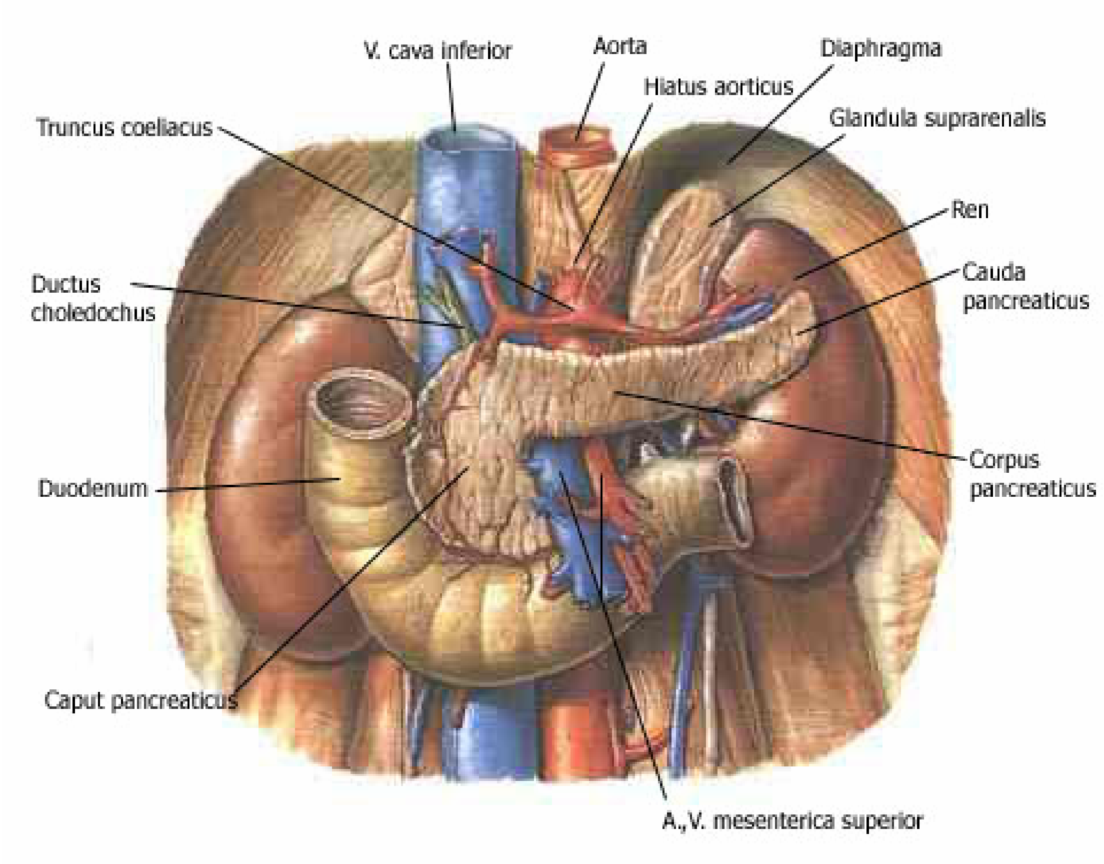


Illustration 2: position of the pancreas in the retroperitoneal space (according to **Sobotta**, 2000)

The pancreas crosses the middle-line of the body approximately at the pylorus. This corresponds with the bisecting point between xiphoid process of the sternum and the navel and has the level of Th 12 – L 2 (Ill. 3).

Illustration 3: topography (according to **Sobotta**, 2000)

At the ventral side the pancreas is covered with the posterior peritoneum and crossed by the root of the *mesocolon transversum*, which is covered with the omental bursa and the *stomach* (Ill. 4). You can also see the close relation of the pancreas and the adrenal gland (*glandula suprarenalis*). There is a fascial connection to the *stomach (plica gastropancreatica*) as well.

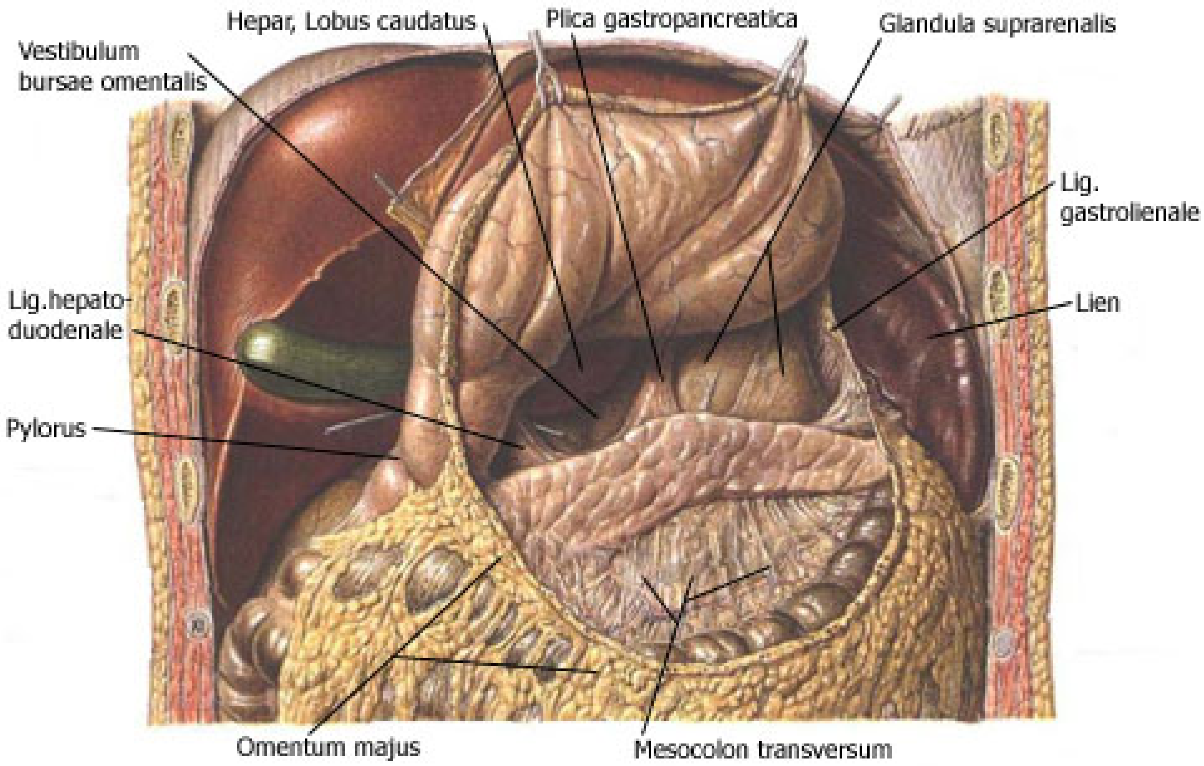


Illustration 4: insight into omental bursa, big curvature with a hook up (according to **Sobotta**, 2000)

The pancreas is a secondary retroperitonealized organ, which means it is dorsally adnated with the retropancreatic fascia (Treitz's fascia). In the sectional view of illustration 5 you can see the relation of the pancreas to the neighbouring structures very clearly. Beginning on the right side, behind the head of pancreas there is not only the *choledochal duct* but also the *receptacles of the right kidney* (That cannot be seen in the illustration!), the *portal vein* and the *inferior vena cava*. Behind the body of pancreas there are the *right pillar of diaphragm*, the *aorta* and the *celiac trunk*, the *lienal artery* and *vein*, the *left pillar of diaphragm* and the *left box of the kidney*.

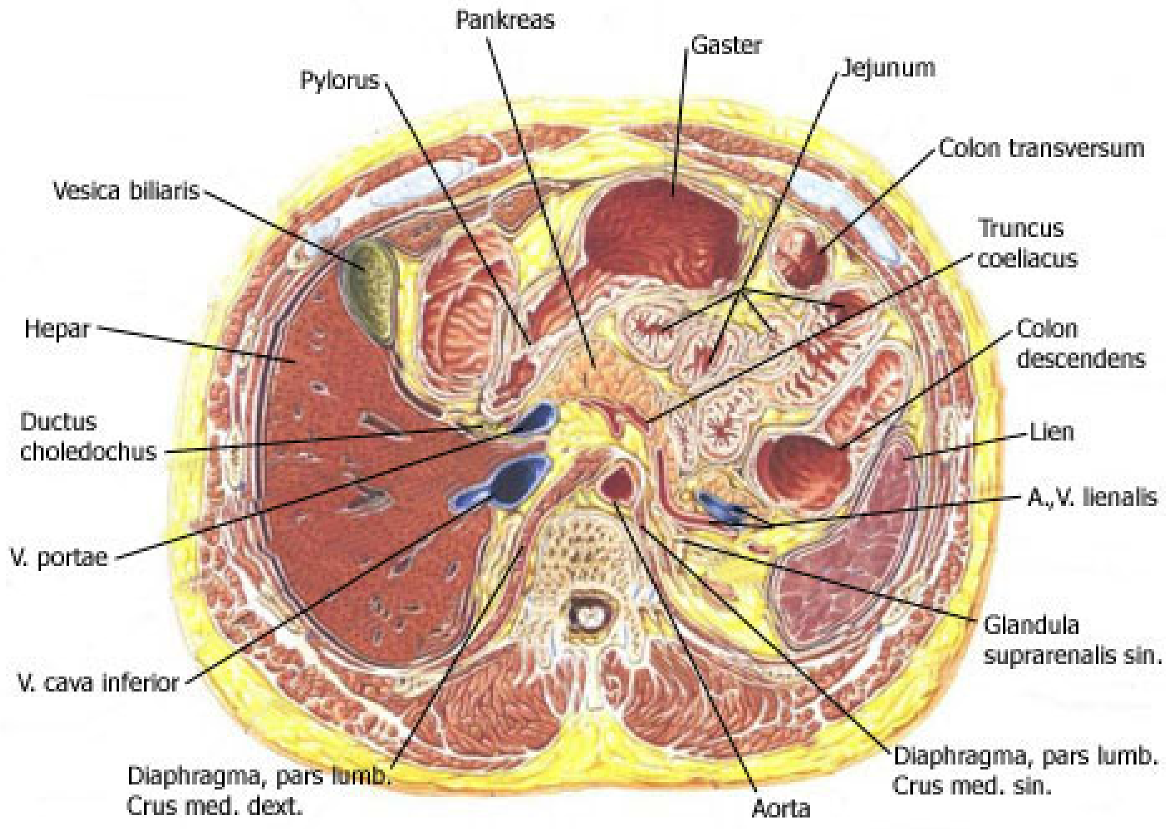


Illustration 5: sectional view at the rate of TH 12 (according to **Netter**, 2000)

Illustration 6 shows the proportions of the three-dimensional surrounding of the pancreas in a frontal level. The *corpus pancreatis* is connected with the *duodenojejunal flexure* over the *transverse mesocolon* and the *root of mesentery*. The *tail of pancreas* is connected with the *hilius of spleen* over the *ligamentum pancreaticolienalis*. At the upper end of the pancreas we can see the *splenic artery*, the *celiac trunc* and the *hepatic artery*. The pancreas is embedded in the *duodenum* and it is held by supplying and draining off receptacles as well (*gastroduodenalic artery, splenic artery, superior mesenteric artery, splenic vein, superior mesenteric vein, portal vein*).

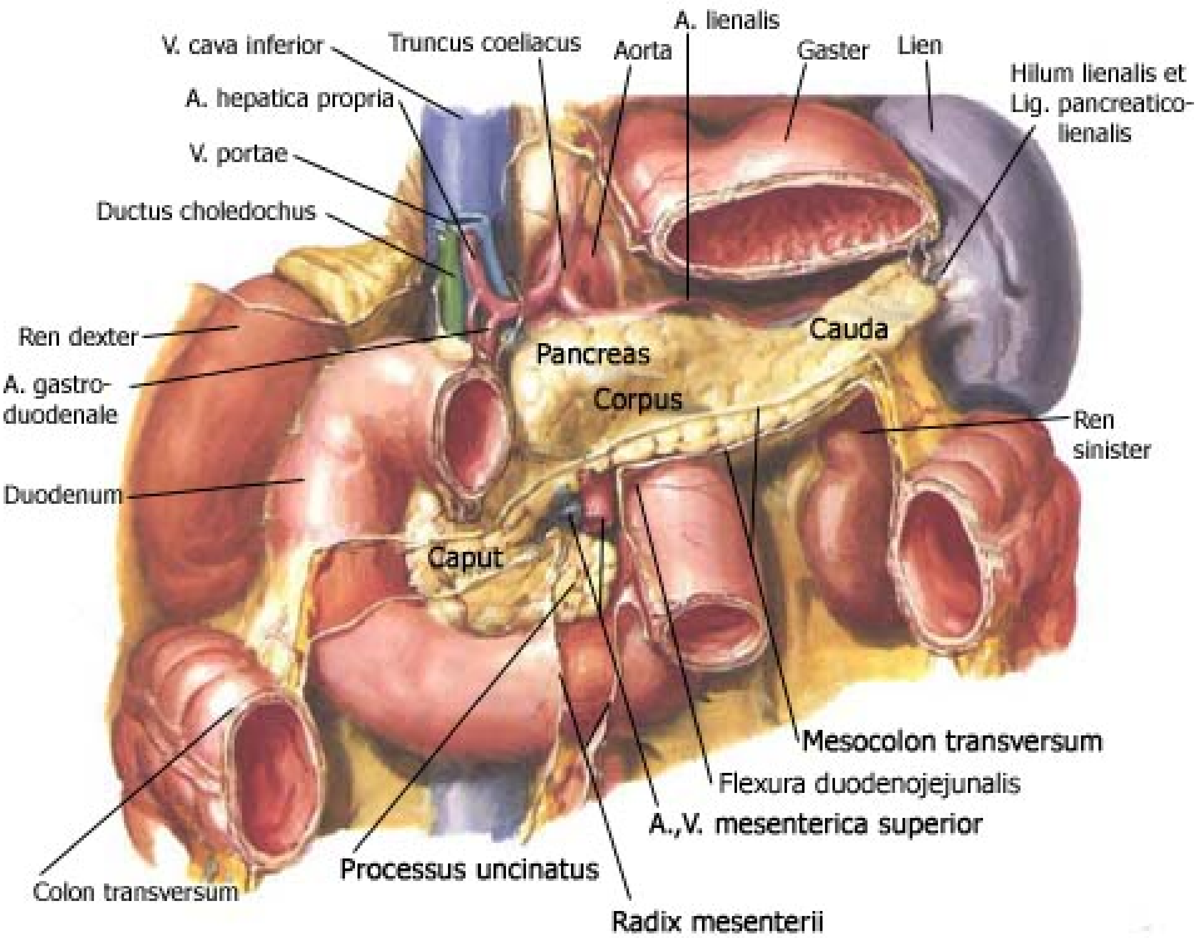


Illustration 6: fixations and connections of the pancreas of ventral (according to **Netter**, 2000)

In the view from dorsal (Ill. 7) we can clearly see the close relation to the *portal vein*. The *uncinate process* nestles up closely to the *superior mesenteric vein*. The *pancreatic duct (Wirsung's canal)* leads, together with the common gal duct (*choledochal duct*) at the major duodenal papilla (Vater's papilla) to the *descending part of the duodenum*.

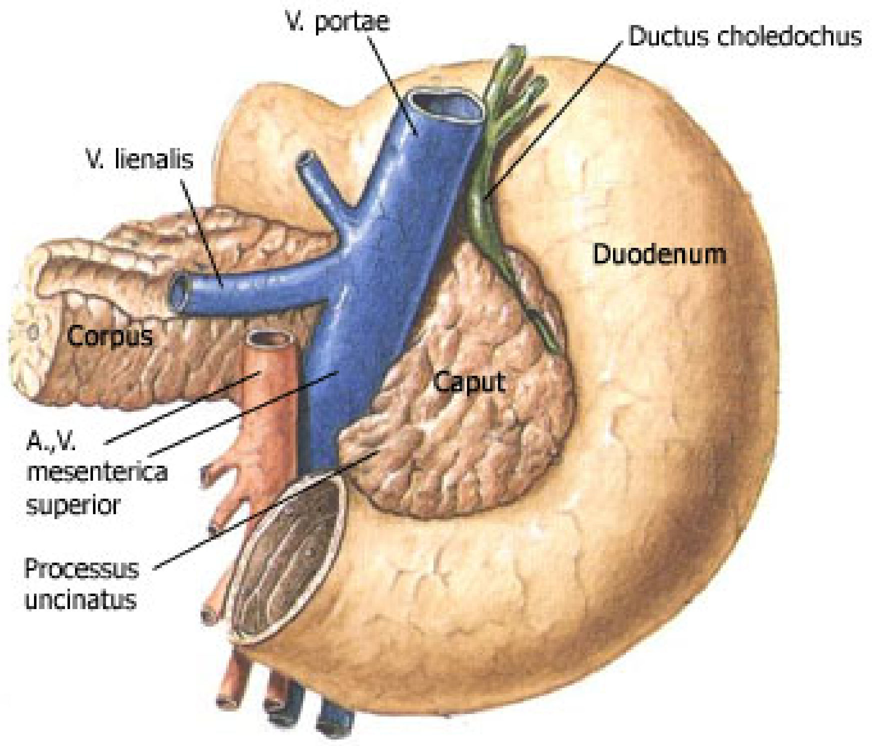


Illustration 7: head of pancreas of dorsal (according to **Sobotta**, 2000)

2.1.1) Vaskularization and Innervation

(cp. **Helsmoortel**, 2002)

The close relation between the duodenum and the pancreas also becomes obvious by their shared neurovascular supply. Two pancreaticoduodenal arcades form arterial circles between the celiac trunc and the superior mesenteric artery. (In this area there is also the transition from front- to middle-intestine.) Parts of the arterial supply come on the on hand from the splenic artery and on the other hand from the inferior pancreatic artery.

The venous drain is similar to the arterial supply. Two venous arcades decongest the pancreas to the superior mesenteric artery and to the portal vein. One part is drained over the splenic vein.

Responsible for the nerval supply are the sympathicus Th 5 - 9 over the major splenic nerve with change in the celiac plexus and the vagus nerve.

2.1.2) Embryology

(cp. **Moore**, 1996)

The parenchyma of the pancreas develops from the entoderm. It emerges from two structures: on the one hand from a bigger, dorsal bud and on the other hand from a smaller, ventral one, which grows close to the orifice of the choledochal duct and is translocated towards dorsal together with the choledochal duct by the duodenum’s clockwise rotation (until the 8th embryonic week). In dorsal the two buds of pancreas merge. (Ill. 8, ill. 9 a-f)

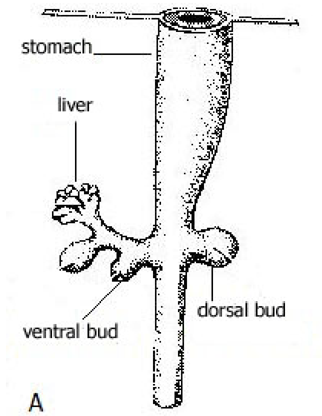


Illustration 8: development of the pancreas (according to **Moore,** 1996)

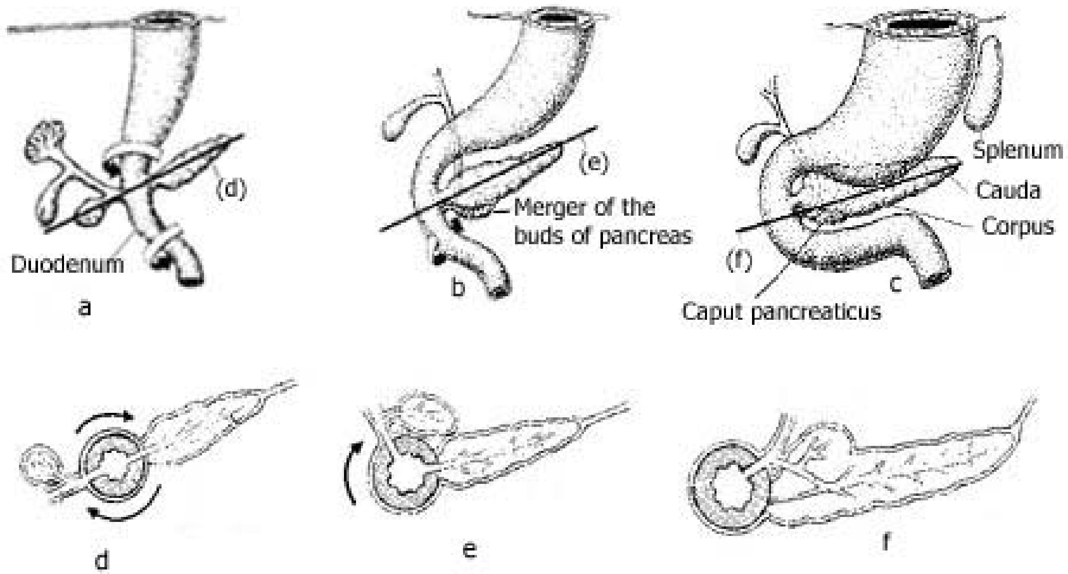


Illustration 9 a-f: merger of the buds of pancreas (according to **Moore**, 1996)

2.2) Physiology

(cp. **Faller**, 2004)

The exocrine part produces one and a half to two litres of juice of pancreas per day, which is passed on to the duodenum by the pancreatic duct (Wirsung's duct) and by the minor pancreatic duct (Santorini's duct), which does not always exist. The production of digestion juice is controlled neurovegetatively (vagus nerve) and humoral-hormonicly by the mucous membrane of the duodenum (secretin, pancreozymin-cholecystokinin). The trigger for its production is on the one hand fat and on the other one a low pH-value of the chyme, which comes from the stomach.

The juice of pancreas has a protein splitting (proteases; for example trypsin and chymotrypsin), a fat- and lipid-splitting (esterases; for example lipase of pancreas) and a carbohydrate-splitting (amylase, maltase) effect.

The smaller, endocrine part releases insulin and glucagon into the blood and therefore it has an important hormonal function, because the islands of Langerhans are the body's only cells, which produce insulin.

3) Visualizing procedure

Ultrasound is a low- risk, relatively cheap and not invasive method for the description of the abdominal organs. **Martinez-Noguera (2001)** was able to show the importance of ultrasound-technique for the diagnosis of the pathology of pancreas. He emphasizes experience and technical skills of the examiner as the most important factor for the best possible result.

3.1) Physical bases of sonography

(cp. **Hofer**, 1997)

To produce an ultrasound image, crystals are stimulated by electric impulses to produce mechanical vibrations. The sound waves spread from the crystals, like from the membrane of a loudspeaker. But sonography uses frequencies of 2,0 up to about 15,0 Mhz, which cannot be registered by the human ear. Several crystals are kept in one sound head. The sound waves spread out in the tissue, are reflected back to the sound head as an echo and there they deform the crystals, which emit electrical impulses again (piezoelectrical effect). These electrical impulses serve to calculate the ultrasound image.

3.2) Echogenity

(cp. **Hofer**, 1997)

Sound waves are reflected at the interfaces between two tissue layers with different conductivities (acustical density) (also ill. 10 a, b). The reflected part of the sound (light blue) is proportional to the height of the density-difference: At middle density-differences (interface A in ill. 10a), one part of the sound is reflected to the sound head, the other part penetrates into deeper tissue layers. If there are higher density-differences (interface A in ill. 10b), the reflected part of the sound is high too and less energy is left for the lower layers.

If the density-difference is so big that all the sound is reflected, it is called total reflexion (black sound shade, which looks white on the ultrasound image), (interface B in ill. 10b). Sound shade (45) can be found behind bones, concrements (kidney- and gallstones) and behind air (flatus).

If there are no acoustical differences, there are no echoes either, e.g. with homogenous liquids like blood, gall, urine, cystic secretion. Ascites or pleura effusion are shown black (without echo) as well.

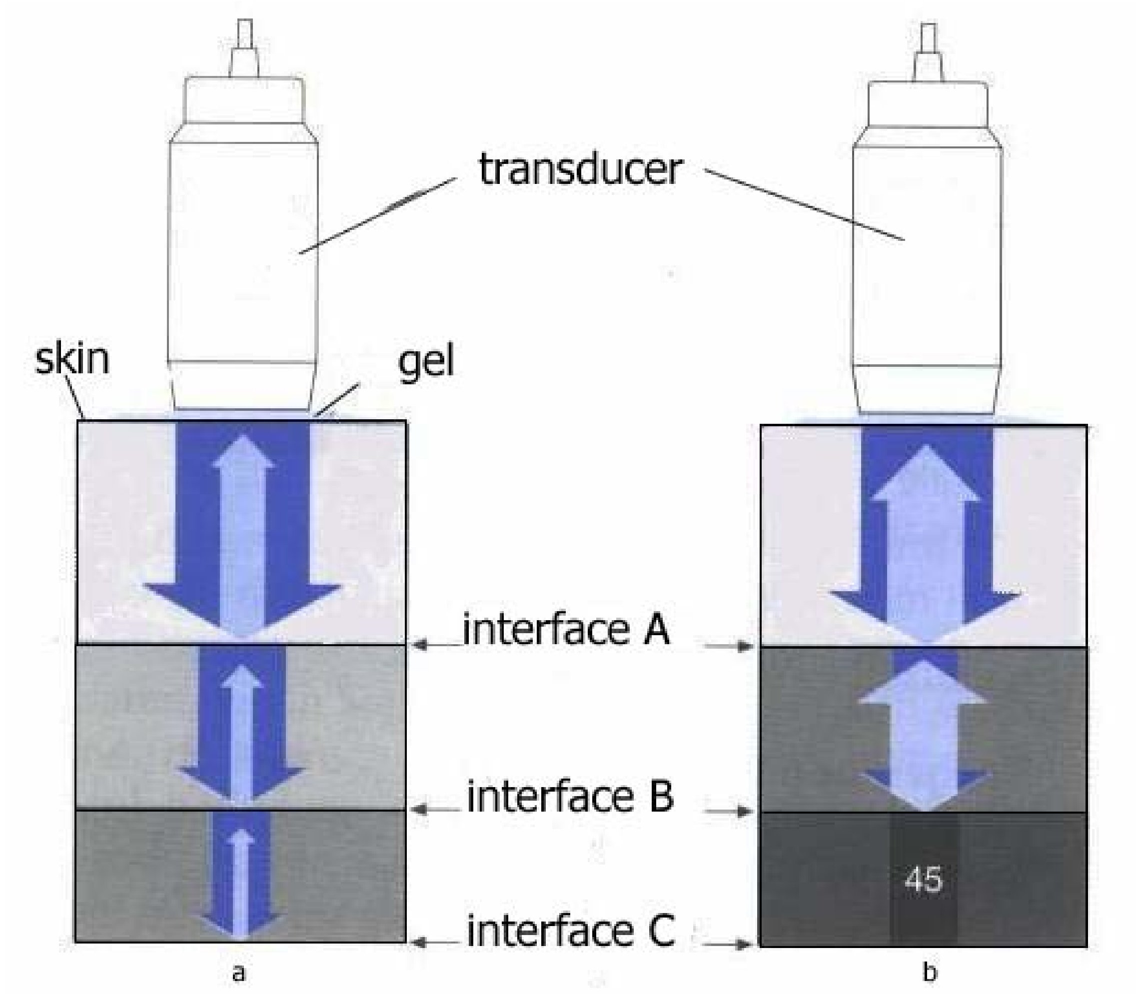


Illustration 10 a-b: echogenity of interfaces (according to **Hofer**, 1997)

METHODOLOGY

We examined 24 healthy persons with ultrasound, using a high-end-instrument (Siemens Sonoline Elegra), a curved-array-sound head (3,0 to 5,0 Mhz) with 4,0 MHZ and a Tissue Harmonic Imaging (THI). Criterions for exclusion were adiposity and diseases of the digestive tract.

The examinations were done in the morning and the examined persons were told just to have a light breakfast (no cereals, no ham and eggs...).

After the individual survey (age, weight, height, operations, deliveries...) the test persons were taught how to do a deep abdominal breathing and just one person had problems with that.

We made images of the position of the pancreas at deep inhalation and maximum exhalation in three positions and three views. The positions were on the back (RL), left half-declination (LSL) and right side position (RSL).

View one is a sagittal view and measures the distance between the cranial edge of the pancreas and the exit of the superior mesenteric artery of the aorta. Therefore the pancreas was projected onto the level of the aorta. For the position of the upper cranial edge of the pancreas of the superior mesenteric artery we wrote a „minus“ and for the caudal position of the reference we put a „plus“ in front the number (ill. 11)

View two is also a sagittal view and measures the distance of the cranial edge of pancreas to the next intervertebral level (ill.11)

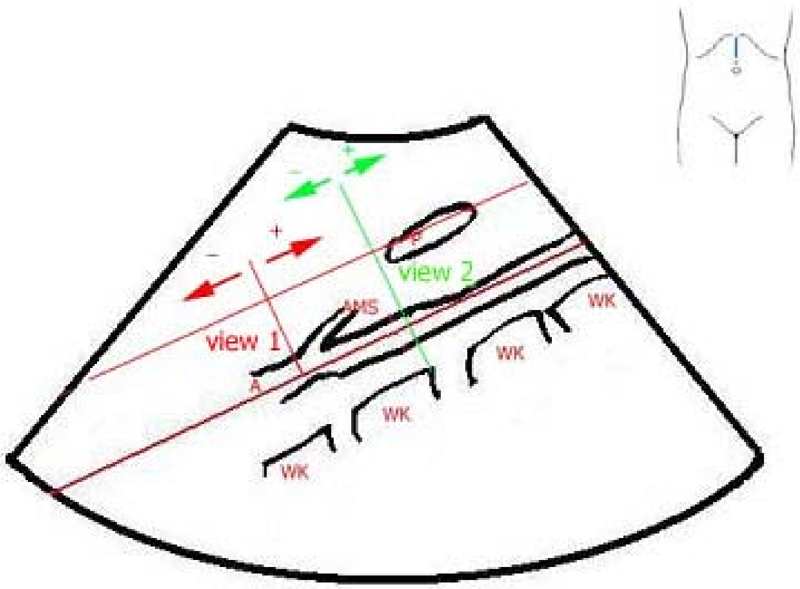


Illustration 11: view one, view two
(A=aorta, AMS=superior mesenteric artery, P=pancreas, WK=vertebral body)

View three is a horizontal view and measures the distance between the medial tail of pancreas and the next intervertebral level (ill. 12). The sectional view was also measured AP.

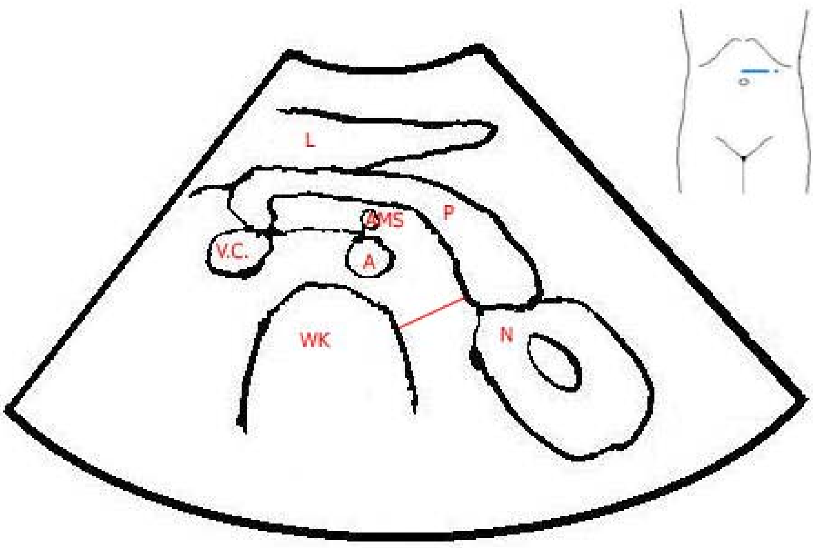


Illustration 12: view 3 (L=lever,VC=vena cava, WK= vertebral body, A=aorta, AMS=superior mesenteric artery, P=pancreas)

The measured distances of inhalation and exhalation of the sonographic views were subtracted and like this we established the dimensions of the movements. The numbers were rounded up commercially to 0,5 and the average sum of the movement-amplitudes was calculated to exactly one comma.

For example:
on the back, view one (superior mesenteric artery to the tail of pancreas)
inspiration 30 mm, expiration 4,5 mm, result: 25,5 mm movement of the pancreas,
or: inspiration 14 mm, expiration -31,5 mm, result: 45,5 mm movement-amplitude

The other inquired facts give information about BMI, age, sex or previous operations or deliveries.
The measurements were taken within two days. Doctor Günther Nics, radiologist in Hollabrunn, Lower Austria, was responsible for all sonographies.
One person had to drink an extra glass of water for a better production.
Two persons had to be eliminated from the study. One, because a layer of fat made it impossible to make an ultrasound image and the other one because of a previous retroperitoneal operation, which had changed the positions of the abdominal organs. We were able to evaluate the facts of 22 persons (12 women and 10 men) from 14 to 66 years.

PRESENTATION OF RESULTS AND DISCUSSION

For a better understanding, here the abbreviations in a short legend:

CC-movement..cranio-caudal movement
RL………………………… on one's back
LSL……………………… left half-declination
RSL……………………… right side position

The pancreas is a very flexible organ. It is influenced by breathing, the position of the body and it is affected by the surrounding organs.

There are important individual influences on the movements of pancreas. Among all the persons we found significant **CC-movement** at view one and two. The movement's amplitudes lie between 0 mm and 64,5 mm or –8 mm.

-0,5 mm is the smallest movement, 64,5 mm means a descending of the pancreas at inhalation and -8mm means a ascending at inhalation.

Looking closely at the personal results in table 1, you can see huge individual differences. Among some examined, the pancreas shows a negative amplitude in view one and LSL and a positive amplitude in view two an LSL. This shows the intraindividual vacillations in the pancreas's movements.

In view one the highest average in RL is 24,2 mm (maximum count 55,5 mm), whereas in view two the highest average movement in RSL is 30,6 mm. (maximum counts: 64,5 mm and -21,5 mm), (table 2).

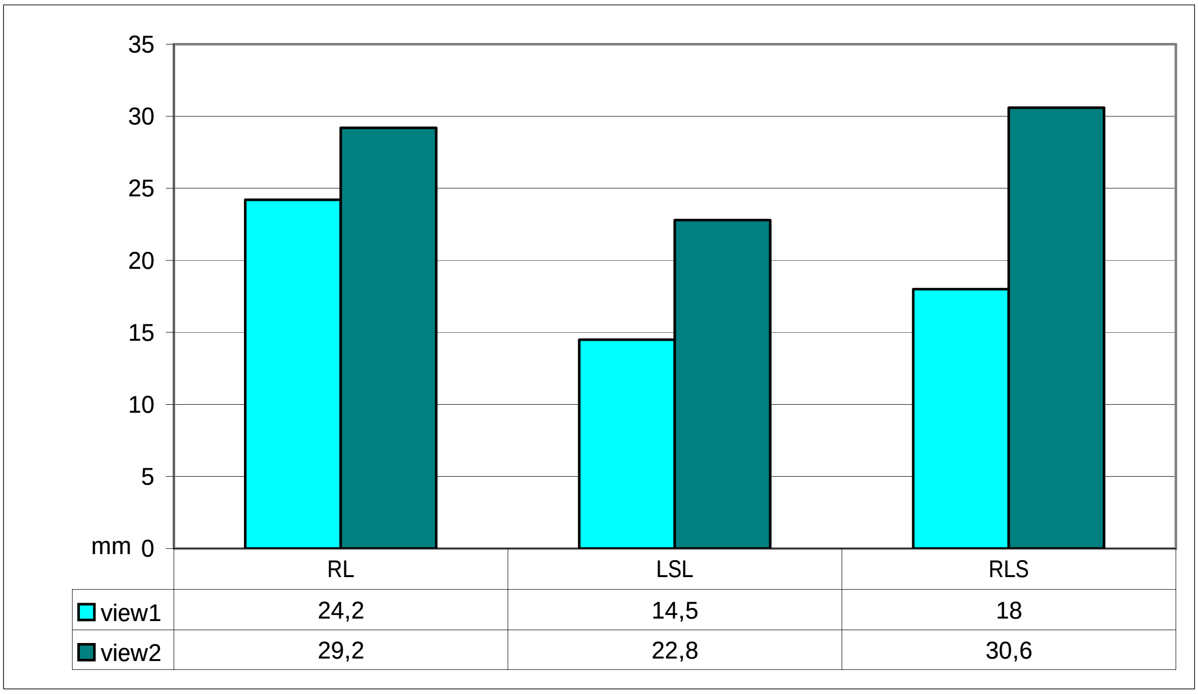
RL view one	***LSL view one***	***RSL view one***	***RL view two***	***LSL view two***	***RSL view two***	***RL view three***	***LSL view three***	***RSL view three***
13,5	-7,5	1,5	10,5	0	-21,5	4	8,5	-0,5
23	6	14,5	23,5	14	27	-6,5	-10	1
23	19,5	12	22	33	23	0	5,5	6
25	35,5	7,5	33,5	18	19,5	-6,5	-9	1
25,5	17	24,5	1	26,5	50	8	11	-2,5
48,5	12,5	8	38,5	18	29	3,5	7,5	19,5
26	16	9,5	43,5	32	13,5	-1	4	-11
40	18,5	32,5	43	46	44	-5	-6	-1
22,5	9,5	31	20	11	39,5	11	2	18
10,5	32,5	13,5	38	27,5	31,5	-7	-8,5	7
27,5	24,5	26	55,5	36,5	22,5	4	-2	-4,5
11	14	-0,5	17	30	15,5	7	11	4
45,5	40	19	53	33,5	48,5	-8	3,5	2,5
23	-8	7	64,5	11	48	0	24	2
55,5	35,5	20	49,5	42,5	34,5	-11,5	-8	-10
10	5,5	22	-0,5	13,5	27,5	5,5	8,5	11
23	13,5	38,5	40	29,5	48,5	-16	-18	-4
19	26	15	19	19	40,5	2,5	10,5	5
30,5	4	30	17,5	31	38	15	10	7
6	-1	11,5	7	6	20,5	1	-6,5	-3,5
5	-0,5	39,5	28,5	11	52	-2,5	1	-2,5
19	7	13,5	17	11,5	21,5	-12,5	-5,5	3,5

Table 1: single results in mm: in every row there are the results of one person. In the gaps you can see the movements of the three different positions (RL, LSL, RSL) in view one, two and three.

	Average amplitude in mm	***Minimum amplitude in mm***	***Maximum amplitudes +/- in mm***
RL/view one	24,2	5	55,5
LSL/view one	14,5	-0,5	40 -8
RSL/view one	18,0	-0,5	39,5 -0,5
RL/view two	29,2	-0,5	64,5 -0,5
LSL/view two	22,8	0	46 0
RSL/view two	30,6	13,5	52 -21,5

Table 2: view one and view two: average values, minimum and maximum amplitudes

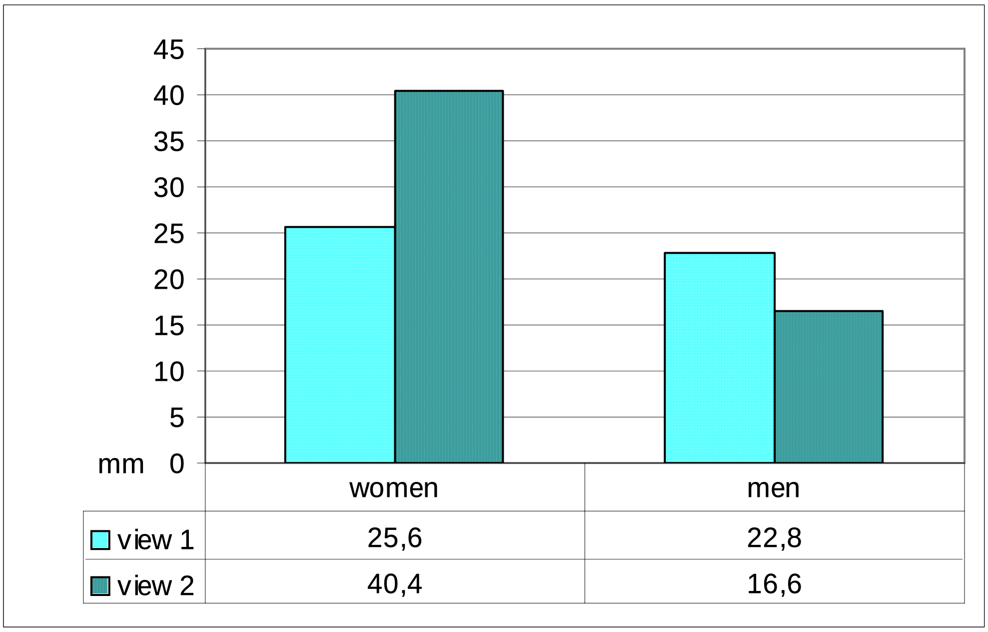
At CC-movement there is a big difference between view one and two.
The dimension of the pancreas' movement in relation to the intervertebral level is averagely 8,6 mm bigger than in relation to the superior mesenteric artery (table 3). That means that the superior mesenteric artery moves with the aorta at reinforced breathing because in view two the amplitudes of the moving are in all positions higher than those in view one. The increasing CC-movement is most obvious in RSL, where the average amplitude in view one is 18,0 mm. The comparative value in view two is 30,6 mm.



	RL	LSL	RLS
view1	24,2	14,5	18
view2	29,2	22,8	30,6

Table 3: cranio-caudal movement in view one and view two

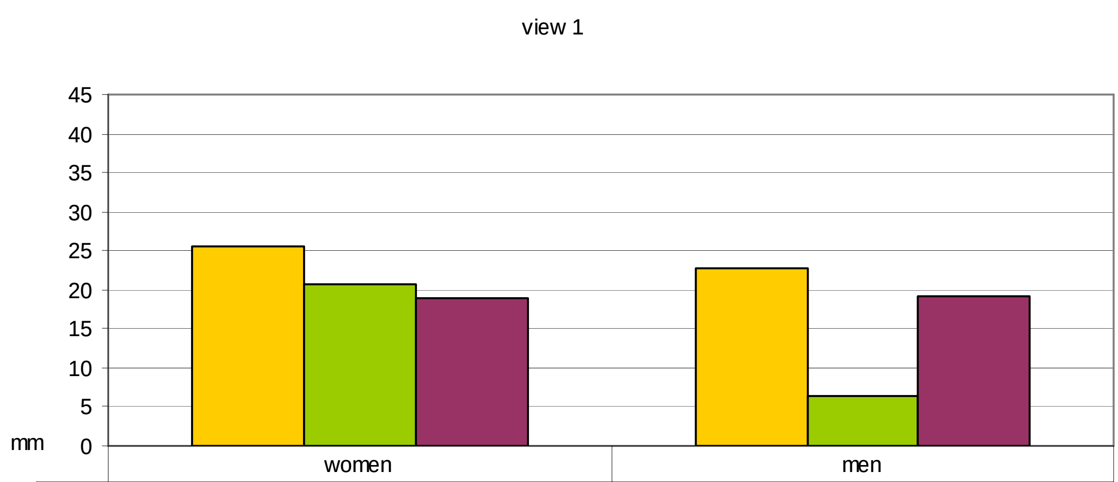
Anomalous are men whose CC-movements in RL in view two are averagely about 6,2 mm lower on the average than in view one (table 4).



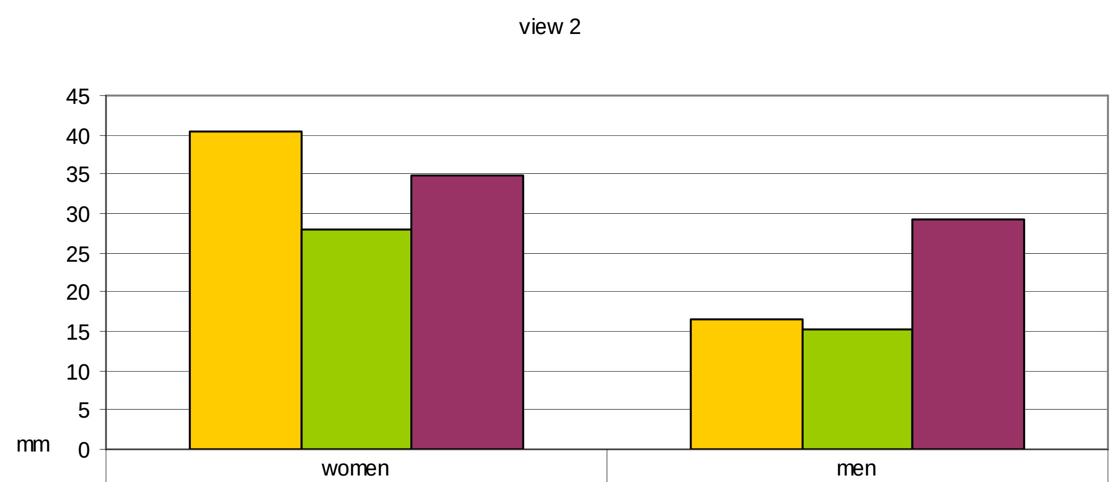
	women	men
view 1	25,6	22,8
view 2	40,4	16,6

Table 4: RL view 1, view 2; comparing the two groups: women and men. Look at the lower value among men in view 2.

Comparing the results of the pancreas' CC-movements of men and women, you see that the women's pancreas is more flexible. (Table 5a and 5b) The most obvious difference can be observed on the back (RL) in view two. The men's amplitude is with 16,6 mm not even half as high as the women's (40,4 mm). Only in RLS (view one), the results are about the same. Among women, the pancreas' movement in RSL reaches averagely 19 mm. Among men it's 19,3 mm.



	women	men
RL	25,6	22,8
LSL	20,65	6,3
RSL	19	19,3



	women	men
RL	40,4	16,6
LSL	28,05	15,2
RSL	34,9	29,3

Table 5a (view one), **5b** (view two): Comparison of the CC-movement in view one and view two between women and men.

The **horizontal movement** of the pancreas is to be divided in two groups.

First: the pancreas moves away from the spine while inspiration.

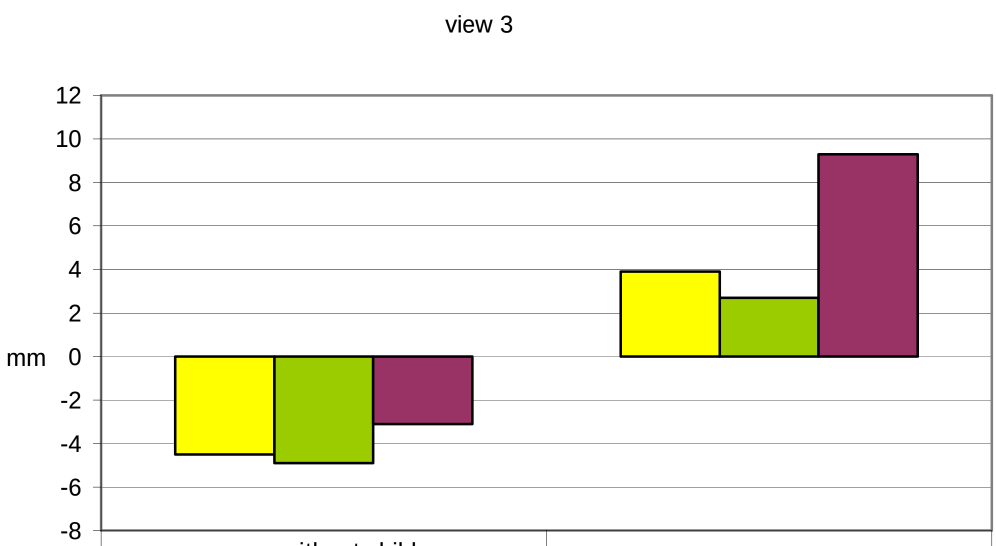
Second: the pancreas approaches the spine while inhalation.

Accordingly, the maximum values of this horizontal movement on the back are with +15 mm and –16 mm quite diverging. In case of +15 mm the tail of the pancreas moves away from the spine and in case of –16 mm the tail of the pancreas approaches the spine at inhalation. Lying on the right side, the maximum value on this horizontal movement is not essentially bigger (+19,5 mm, -11 mm). The amplitudes in LSL are the highest in both directions. (+24 mm, -18 mm).

	Average amplitude in mm	***Minimum amplitude in mm***	***Maximum amplitude in mm***
RL view three positive amplitude	6,2	1	15
RL view three negative amplitude	-7,7	-1	-16
LSL view three positive amplitude	8,2	1	24
LSL view three negative amplitude	-8,2	-2	-18
RSL view three positive amplitude	6,7	1	19,5
RSL view three negative amplitude	-4,4	-0,5	-11

Table 6: view three, average values, minimum and maximum amplitudes in both directions, positive and negative

Looking closely at the two groups with the opposing movements of the pancreas, a tendency becomes obvious. The group, whose pancreas approaches the spine while inspiration, consists mainly of women who have never given birth. The other group consist mainly of men. Among women, you can see an approach of cauda of pancreas to the spine at inhalation in all three positions in view three and among men the tail of pancreas approaches to the spine in all positions at expiration. (table 7)



	women without children	men
RL	-4,5	3,9
LSL	-4,9	2,7
RSL	-3,1	9,3

Table 7: view three RL/LSL/RSL; women without children, men

It is also important to see that the approach to the spine is small, but the deformation to a „croissant“ is still obvious (ill. 13a-b). The deformation of the pancreas in itself can be seen in ill. 13 a-b as well. During exhalation, the pancreas seems to increase in length and the cauda pancreaticus shifts towards dorsal.

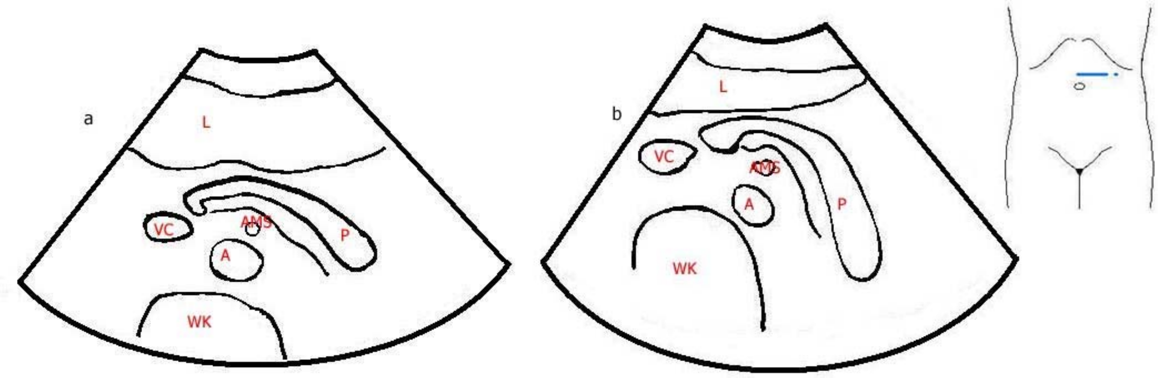
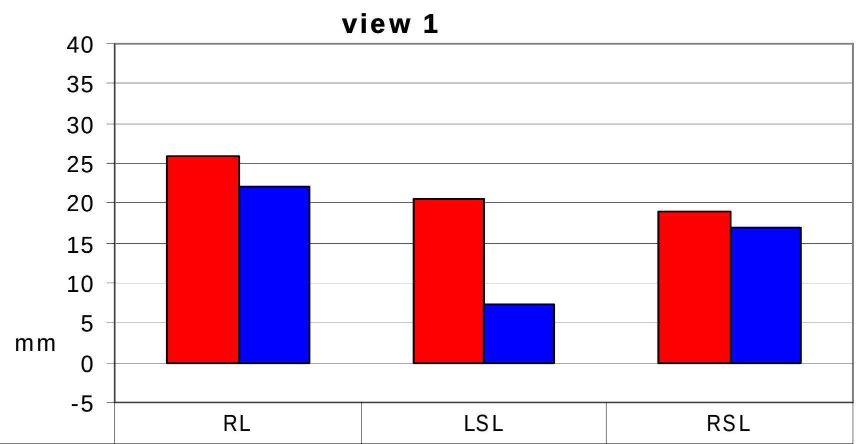
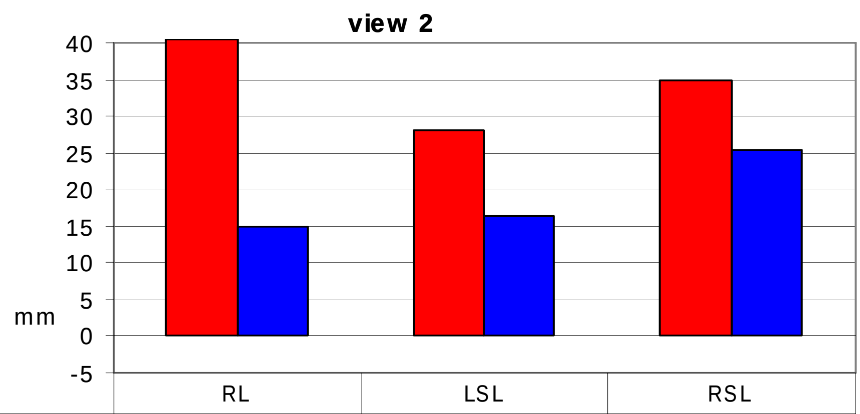


Illustration 13 a-b: croissant-deformation (a=inhalation, b=exhalation, L=liver, P= pancreas, VC= vena cava, A= aorta, AMS= arteria mesenterica superior, WK= vertebra)

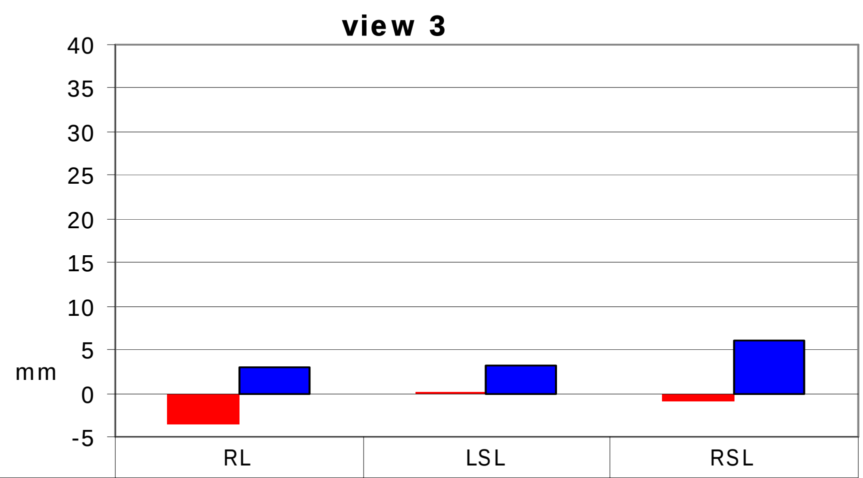
We saw that the women have a bigger movement than the men in cranio-caudal direction (view one and view two). In horizontal level (view three) the movement amplitudes seem to be bigger among men (table 8a-c).



	RL	LSL	RSL
Women	25,92	20,63	18,96
Men	22,15	7,25	16,85



	RL	LSL	RSL
Women	40,42	28,04	34,88
Men	15,05	16,45	25,45



	RL	LSL	RSL
Women	-3,67	0,21	-0,96
Men	2,9	3,1	5,95

Table 8 a, b, c: difference between women (red) and men (blue);
a= view one, b= view two, c= view three

The average age of the examined persons is 37 years. The average body mass index (BMI) was with 21,4 very low due to the participation of three teenagers. Excluding these three teenagers the BMI rises up to 22,1. We could not find a tendential relation between the dimension of the movements of the pancreas and the BMI. However, the amplitudes of the movements of the teenagers are below the average to a great extent.

The profile of pancreas was measured in RL AP and averages 9,7 mm (minimum 5,5 mm, maximum 12 mm).

We should also pay attention to the following phenomenon, which have not been examined specificly in this study: As shown the pancreas changes its position not only at forced breathing. Due to a shift of position of the examined the pancreas varies its form and position (ill. 14 a-c).

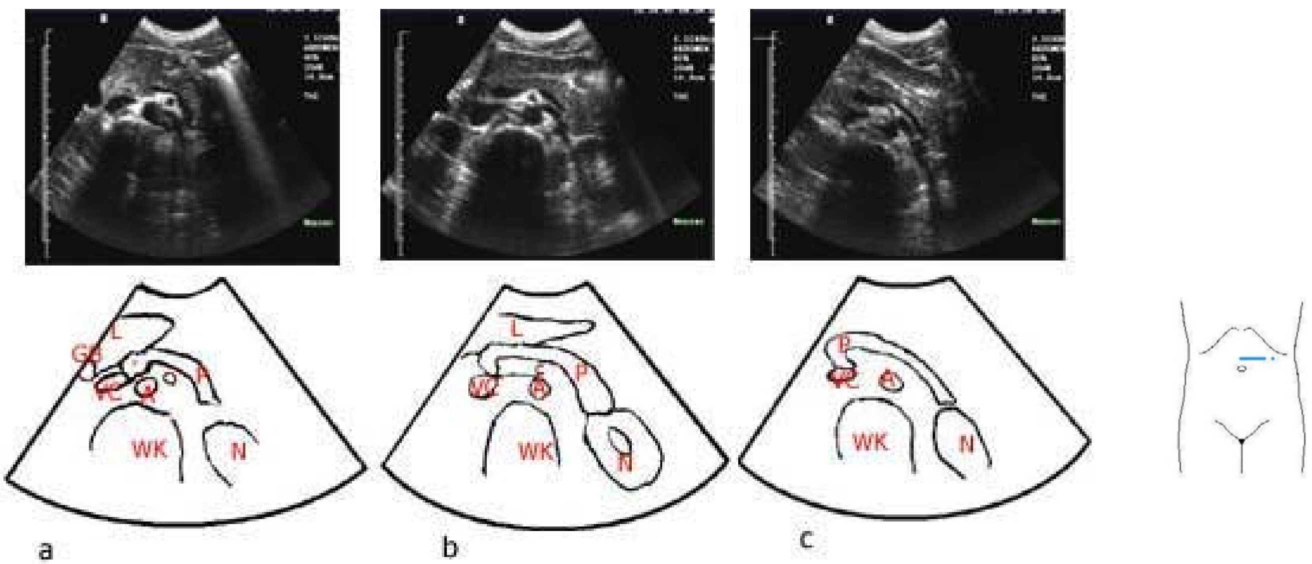


Illustration 14 a-c: changing of form of pancreas in reliance on the position of the examined person (a=LSL, b=RL, c=RSL; L=liver, GB= gallbladder, VC= vena cava, A= aorta, P= pancreas, WK= vertebra, N=kidney)

The position of the kidneys and the aorta remains constant in all three positions, but the liver changes its position. In LSL (a), the liver seems to press the pancreas away from the vena cava. The pancreas changes its form and seems to become shorter in LSL, while it extends in RL (b) and RSL (c). The liver cannot be seen in RSL, because it slides to the right and permits the extension of the pancreas.

Kidney's influence can be seen from ill. 15 a-b. While inhaling, the left kidney lowers itself towards caudal and ventral. Thus it seems to prevent the approach of the pancreatic tail towards the spine. Therefore the pancreas deforms itself and seems to become longer. The same illustration shows that the pancreatic tail is more flexible than the pancreatic body. The corpus pancreaticus – between liver and vena cava – keeps its characteristic C-form while inhalation and exhalation.

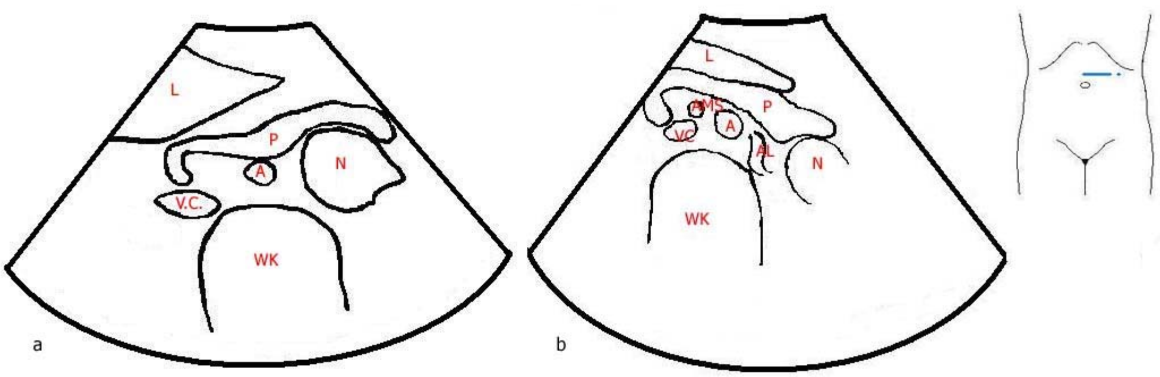


Illustration 15 a-b: kidney's influence in view 3 (a=inhalation, b=exhalation)

On the whole there is a bigger cranio-caudal movement noticeable at the tail of pancreas than at the caput. This would confirm **Kivisaari's** study (1982), which showed with computed tomography a breathing-induced movement (adequate respiration) of the pancreatic tail up to 9o mm. The pancreas caput moves up to 56 mm.

The results of **Bryan et al.** (1984) are partly comparable with the present ones. With 18 mm and 22 mm, the average amplitudes while lying on the back and on the sides, correspond largely with the values measured in view one
(RL: 22,4 mm; LSL: 14,5 mm; RSL: 18 mm). Bryan describes a movement of the pancreas towards the arteria mesenterica superior up to 30 mm. The difference between view one and view two (corresponds with the movements of the pancreas towards the arteria mesenterica superior) has an average value of 8,9 mm, but a maximum value of 41,5 mm.

Hebgen's (2001) description of the diaphragm as the driving force of the fascial movement of the abdominal organs is quite comprehensible.

SUMMARY

With the help of ultrasound it was possible to show the mobility of the pancreas at forced breathing. Even though there are big individual differences, the cranio-caudal movement is noticeable and due to an average mobility of 30,6 mm, it is possible to compare it to the kidney's mobility. The dimension of the movement in horizontal level is very small and shows higher differences. The influence of the neighbouring organs, especially of the left kidney and the spleen, is variable and rarely predictable.

An important result of this study is the inducation of the changing of form and position of the pancreas at different positions of the examined person.

FINAL STATEMENT

The work of an osteopath requires good anatomical knowledge. Ultrasound is an examination technique, which explains anatomy of the living person. I think, the treatment of sonography is a good possibility – also for interested osteopaths – to improve their anatomical orientation.

While talking about flexibility or mobility of organs in osteopathy, it is necessary to mention the driving force of movement. It is important to emphasize the difference between mobility and motility. According to my opinion an organ's good mobility – as shown in this study for the pancreas while forced breathing – is a condition for the function of the organ.

It is essential to osteopathic techniques to adjust the movements of the hand in different positions to the changed relations of the positions of the inner organs

The individual differences of the pancreas' way of moving while forced breathing should encourage osteopaths, to adjust acquired techniques to the patient and not to use a common recipe.

The influence of the straight posture on the mobility of the abdominal organs was not examined in this study and until now it has not been subject of osteopathic or medical research yet. Studies in this direction would also be possible.

Surprisingly, medical studies, like those of Kivisaari (1982) or Bryan (1984), have not been considered in osteopathic literature yet.

I also would like to thank Dr. Günther Nics for his ambitious support. Without his sonographic abilities this work would not have been achieved.

I also want to thank Mag. Wolfgang Lausch for his help on the computer and to Agnes Lausch and Anna Walchshofer thanks for the translation.

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CATALOGUE OF THE TABLES

CATALOGUE OF THE ILLUSTRATIONS

APPENDIX:

Data sheet:

age: sex:

☐ *male* ☐ *female*

height:

weight:

preceded operations (abdomen or thorax):	when

preceded deliveries	when

diseases of digestive organs: yes no

☐ ☐

if yes, which ones:

Survey:

	AMS – pancreas	ZWR – pancreas	WK - cauda
RL: inspiration			
exspiration			
LSL: inspiration			
exspiration			
RSL: inspiration			
exspiration			

sectional view of the pancreas: ....

disease of the pancreas, which is noticeable by sonography: ....

....

....

Declaration of consent:

name ....

With this I agree to the planned ultrasound examination

and I consent to the publication of the anonymized facts.

date .... *signature* ....

(with minors legal guardian's signature)

Ultrasound images of one person:

You can find all ultrasound images on a CD –rom at the Vienna school of osteopathy WSO.