M.I. Prudkov
“The basis of mini-invasive surgery / Basis of small access surgery”.
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M. I. Prudkov – Doctor of Medical Science, professor, the head of the surgery department at the faculty of advanced training and post-diploma practice in the Ural State Medical Academy, the surgeon-in-chief of the Sverdlovsk region.

The author presented his own understanding of small access surgery from the position of general surgery.

In this work classical criteria of surgical access suggested by A.U. Sozon-Jaroshevitch have been developed and a wide range of new statements, principles of evaluation of local and general surgical trauma have been stated.

Also the analesis of endosurgical techniques is presented, including the access assisted by peroral fibroscopy, trans fistula and puncture navigation procedures, small access surgeries, video laparoscopic surgery and robotic surgery.

The book is designed for surgeons and doctors of surgical specialties.

Pictures – A.P. Shushanov

Introduction

Mini-invasive surgery is the branch of modern medicine, which minimizes the injuries of the organs and tissues due to surgical intervention. (Latin: “minimus” – the smallest, minimal; invasion – intervention).

Firstly, the decrees in operative treatment invasion were focused on soothing physical sufferings of the patient during the post-operative period. Later, this method proved to result in consequences such as: decrease in complications and fatality, shorter treatment and rehabilitation period, clearly observed long-term functional and cosmetic consequences, economy of materials costs.

The latest advances of scientific progress and the total growth in prosperity made mini-invasive surgery the major field developing of the surgery. In addition, the rate of its introduction into daily practice has become a technological revolution. As the case stands the necessity of designing the general surgical theory, describing both conventional and mini-invasive operations is essential.

There is hope that this work will help to move closer to its appearance.

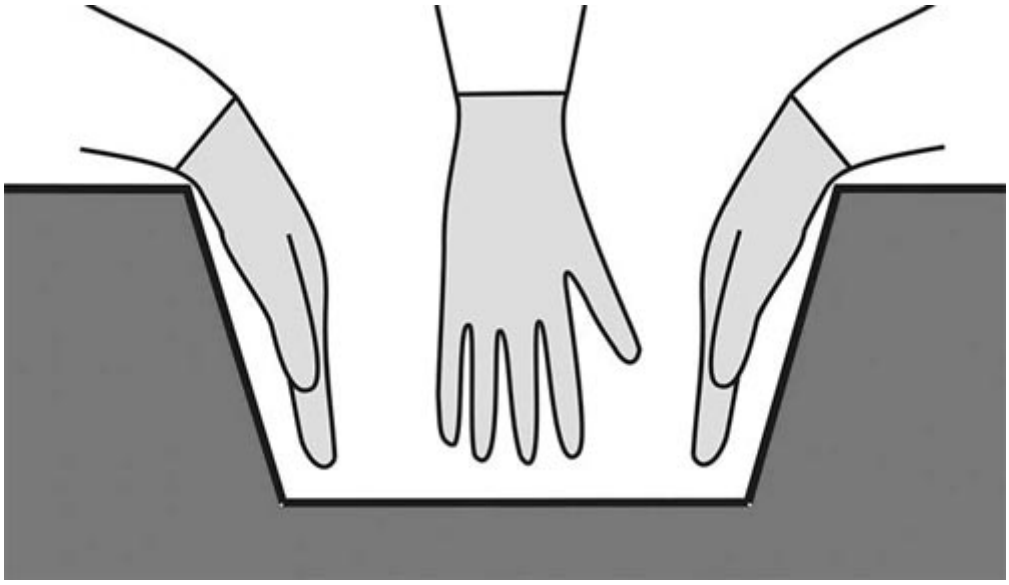
Theoretical basis
Surgical approach

“Proudly we can say that it was Russia where a sect requiring a special presentation of problems concerning surgical approach appeared and gradually was shaped. It is a scientific sect based on studding of the anatomo-physiological peculiarities of the human body.

This method places two demands on operative approach:

1. It has to be less traumatic; it mustn’t affect body functions.
2. It has to provide the necessary space in the wound…” A. U. Sozon-Jaroshevitch (1954).

In the conventional surgery the major mission of access is to create conditions for free manipulations on organs and tissues, similar to the work conditions on the outer surface (Picture 1).



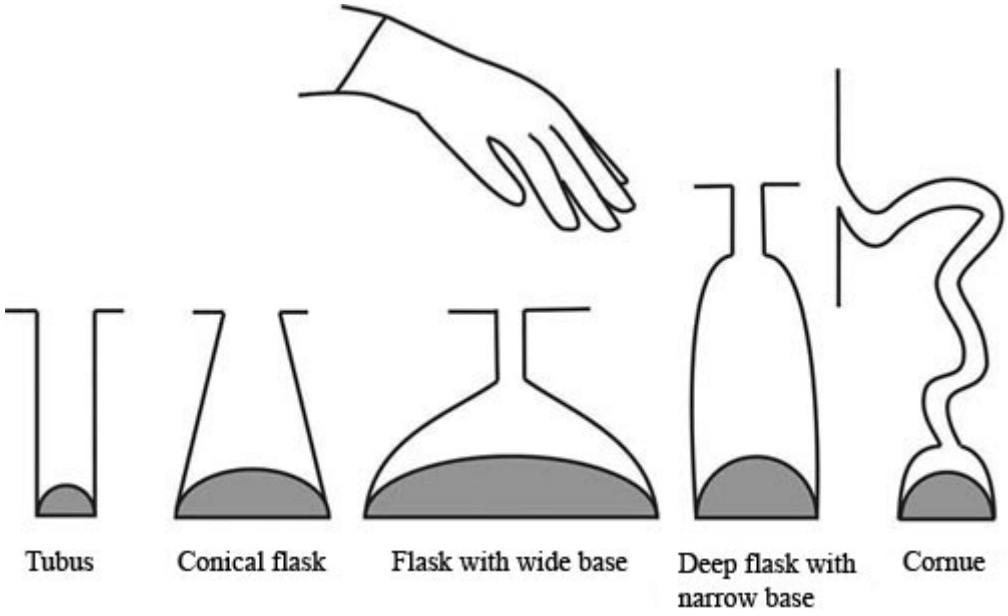
(Picture 1) Conventional approach through the large intersection provides extra latitude for the actions of a surgeon in the wound

It must be wide and must create the necessary space for inserting hands and free manipulating with the object of intervention. Hands occupy a part of free space. At the same time the rest of the space must be enough for observing, inserting and manipulating with the instruments, inserting extra devices and etc.

The final aim of forming an approach in classical surgery is creation of free conditions for the open manipulating on the outer surface. The wider and freer the surgical approach, the closer the conditions to the work on the outer surface.

In mini-invasive surgery the small accesses are more common, that arouse appearing of another term for this branch – minimal access surgery.

The characteristic feature of minimal access is the prevalence of forms, common to the laboratory vessels, with relatively narrow orifice and more capacious basic space. (Picture 2)



Picture 2. Types of accesses for mini-invasive surgery.

A part of free space is marked by darker color that proves ease for the surgical operation.

The conditions of minimal access exclude the possibility of direct manual intervention on the object, which is common for the classical surgery. The possibility of exteriorization, which means bringing of the object of intervention onto the surface in order to make the operation easier, does not always exist.

That's why the main method of carrying out the mini-invasive surgery is apodactylose (Greek: "apo" – separation, split, stopping of the action, "daktylos" – finger) – interventions with a help of instruments inside the organs and tissues. Thereat fingers and hands of the surgeon are out of the wound and the instruments are inside the organism. This fact is stated also by another name for the mini-invasive operations: endosurgery (Greek: "endo" – inside; "cheir" – hand; "ergon" – work).
According to the features of the accesses all mini-invasive surgeries can be divided into following types.

Types of mini-invasive surgical interventions:

- Natural
- Fistulous tract
- Through the wounds

a) Paracentetic (Latin: "punctio" – nyxis)

b) Incisional (Latin: "incisio" – incision, discission)

The characteristic feature of intervention made through the natural route is the existence of a natural barrier of mucous coats, protecting surrounding tissues from infections and submucosal layer, damping the mechanical effects. Tissue damage and risk of contamination in this case is minimal, and after the operation there is no outer wale.

Fistula operations are made using the already existing cicatrical canal with the walls of granulation tissue. Granulation tissue is also a natural barrier for infections and the dumb from mechanical damage, although it's less effective than skin and mucous. If the integrity of granulation is safe, there is no tissue damage. There is no risk of its contamination. After such operations fistula is being healed with forming of a point scar. Fistula operations also do not leave new scars.

At the same time operations made through the fistulous tract are considered to be more risky as compared to the operations made through the natural route. In the area of fistula canal there is cryptogenic infection, it is usually rather aggressive and can cause complications even in the case of minimum injury of fistula canal.

Incisional wounds used as accesses are less protected from contamination and mechanical damages. During the operation the walls of the wounds are constantly being exposed to mechanical injuries. After the operation the damaged tissues are exposed to the inflammatory changes, undergo the period of functional diseases and very often are subject to contamination. Healing always results in the scar forming and appearing of the constant distant functional diseases resulting not only from a disease or surgical intervention but also by the access itself, used for conducting this intervention. At that the consequences of intervention may be quite severe.

Centesis is a wound made by narrow long instrument with a sharp end. Such wounds have a long narrow canal and after extrication of the instrument the wound lumen is distorted and falls down. Using this type of access there are few tissue damages. So the consequences of these damages are few either.

These facts make punctures one of the most widely used types of surgical approach for the minim-invasive interventions.

Risk of paracentetic access is mainly in the procedure of puncture itself, when a piercing instrument damages organs or tissue structures, passes through natural atrium and so on. This risk can be diminished by though developing of the path of moving the instrument, and with the usage of special equipment and methods of observation.
Incised wounds of small size are also used as the access in minimal access surgery. For the determination of these accesses the appropriate terms are used (mini access, minilaparotomy, minithoracotomy, minilumbotomia), which shows their small size and the non-presence of adequate conditions for the use of classical surgical technique.

Incisional access is made with a help of cutting instruments layer by layer following all the safety requirements, necessary used in open surgery. In the process of operating the access walls are not protected from extra traumas and contamination, that's why they require the same approach as in the conventional surgery (coating of the operation site or using of sterile sticking surfaces, isolation of wound layers with material and etc). At the end of operation the mini access needs sewing layer by layer.

This way of access has such consequences as more manifested local tissue trauma, risk of the wound infection and rougher scars.

Manipulation control Observation

There is one more feature of mini-invasive operations, which is the wide use of special methods of observing the object of surgery and the instruments.

Endoscopy (Greek: "endon" – inside; "skopeo" – see, observe). It's a method of visual examining of tissues, organs and cavities inside the organism and not available for external examination.

Endoscopy unites a wide range of techniques ranging from simple "looking" behind the edges of natural external openings, wounds and fistulas with a help of special dilatants and mirrors (laryngoscopy, otoscopy and rhinoscopy, rectoscopy, colposcopy, lumboscopy, vaginascopy, mediastinoscopy) before the usage of complex optical equipment and systems: cavascopes, using lenses (rectoscopy, bronchoscopy, thoracoscopy, laparoscopy, cyctoscopy etc.), fiber optic (fiber-optic bronchoscopy, fibergastroscopy, etc), endo-video equipment sending visual pictures further – from the eyeglass of cavascope to the monitor (video laparoscopy, video thoracoscopy) and electronic devices receiving element of which (e.g. micro-video camera) is situated direct on the working tip (electronic endoscopy).

Video endoscopic control attracts surgeons fist of all because of its opportunity to have a usual and high quality pictures of surgical area with high resolution. This technology also has its own limits, optical and electronic distortions.

Technological carrying out of this procedure can be related to the special negative consequences. So, peroral endoscopy requires insufflations and widening of lumen of revised part of gastro-intestinal tract by the air flow. At that point there is a possibility of stomach content regurgitation in to the bronchi.

Laparoscopy requires the creation and maintenance of tense pneumoperitoneum during the whole operation that can negatively affect the functioning of breathing and cardiovascular system.

Ultrasound investigation, roentgenoscopy, X-ray television, CT (computer tomography), MRT and etc. are also widely used in the mini-invasive interventions.
Advantages of these technologies to a large extent are explained by the peculiarities of radiation – liberality, which are explained by the parameters of surgical approach, a possibility of getting additional information about neighboring structures and lumps situated on the way of surgical access, peculiarities of blood flow, density of operated tissues.

Existing limits – artificial colors and flat nature of final picture, distortions and aberrations.

Application of techniques connected with radiation exposure can be accompanied by and can be related to negative consequences (roentgenoscopy, X-ray television, CT and etc.)

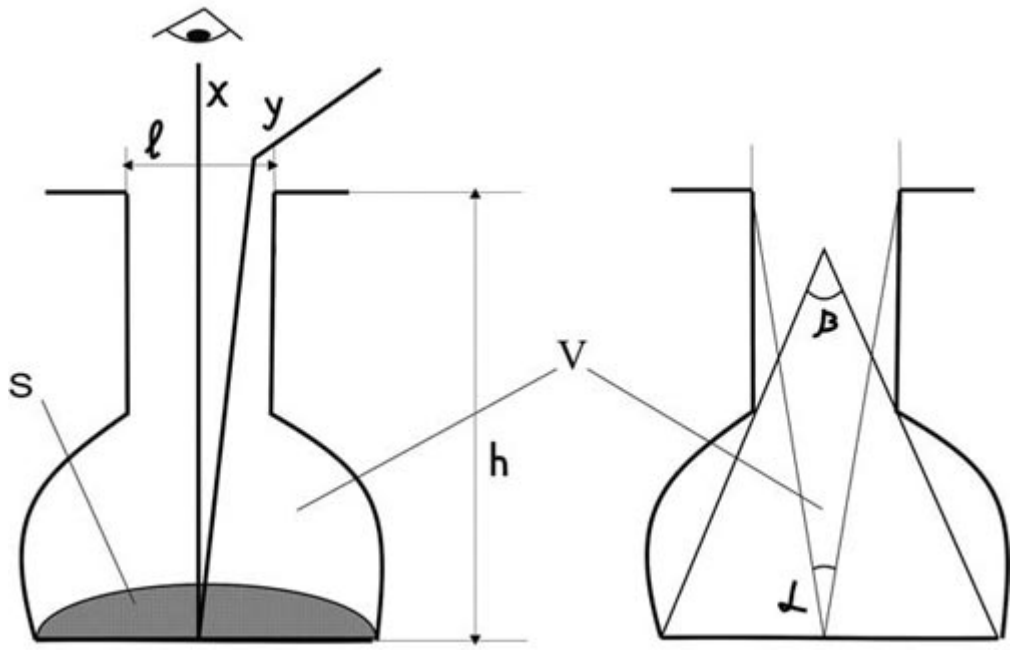
Tactile senses

Another feature of mini-invasive surgery is the predominance of mediated tactile senses (instrumental palpation) which divests a surgeon of the important information and operative skills.

The degree of indirectness depends on the number of factors (type of instrument and hand contact, instrument toughness degree, inner friction expenses) and can essentially influence the degree of reliability of operation.

Criteria of access evaluation

Mini-invasive operations, along with conventional operations, require evaluation of adequacy of surgical approach. Unfortunately the classical criteria elaborated by A.J. Sozon-Jaroshevitch are quite difficult to use for this purpose.



In accordance with the changed conditions we tried to insert the necessary corrections. (*Picture 3)*

L – Length
X – Axis of observation
H – Depth
S – Accessibility area
V – Volume and shape of operation wound
Y – Axis of operating action
- angle of operating action
- angle of operating action endosurgical

Length and depth. The characteristic feature for mini-invasive operations is the prevalence of depth over the length. The more is the depth in comparison with the access length, the less spacious the operative conditions are.

Axis of observation – is the line of sending the image that connects eyes of a surgeon and operation object. Unlike the standard operations in mini-invasive operations this axis can be performed not only as a straight line. It can consist of several segments of straight lines (broken line), can be bent, and can have a complex shape and even virtual segments.

In the process of operation the axis of straight vision of an object of operation should be free and not interfered by the hands of a surgeon and instruments.

When observing through the access the shape of axis observation is determined by its parameters. But when using the radiation methods of observation through the tissues the observation axis shape doesn't depend on the access.

Picture 3. Criteria of evaluation of accesses for mini-invasive operations.

Axis of operating action (physical efforts sending line connecting the surgeon hands and the object of operation) can be represented in the way of zigzag, straight and bent line. It can also have virtual segments. The longer, the more complicated in the shape the line is, the more difficult to operate.

In mini-invasive surgery the axis of observation and the axis of operating action do not coincide. While using the access simultaneously for observation and operation, somewhere they can situate parallel not shadowing each other.

Accessibility area. One of the features of mini-access operation is the tightness of surgical approaches, in the result of which only some parts of organs and structures are accessible.

The correct understanding of what chamber of organs become accessible to a large extent determines a success of mini-access surgery.

Volume and shape of operating space. For mini access surgeries we use spaces different in volume.

Shapes of operating spaces are specialized for different operations. As an example it can be access: in the shape of "tubus" used for manipulating rectoscopy and mediastinoscopy, "retorts with wide base" used for video-laparoscopy and video-thoracoscopy, "retorts" used for fibroscopy.

The prevalence of flask shapes is not accidental. The widening surgical space is several times larger in volume than cylindrical one. If we consider the operating space from the position of significance of its chambers for freedom of operating, it's easy to notice that flask shaped operating space is more preferable.

It allows to maximize the space, situated right above the accessibility area. The wider the volume of free space, the easier it is to operate.

The widening of this part of access duplicates 4 times the area of the accessibility, and the volume of free operative space is 8-times as much.

So, flask-shaped access provides the largest operative freedom in the accessibility area with the minimal volume of operating space, and minimal contact surface of instruments and tissues.

Angles of operating action – are important criteria for evaluation the preciseness of surgical approach and freedom of surgery.

The most important characteristic of evaluation of possibilities of classical surgery in the conditions of wide access is the angle of operating action (AOA classical or AOAC). It's formed by the lines connecting

outer edges of an access and the particular point of operating object. Adequate favorable conditions for using general surgical technique of manual intervention arise when the angle is 25% and more.

The common trait of mini-access surgeries is the necessity to manipulate at smaller AOAC. E.g.: when operating from mini-access on the object shifted from the wound its value is 15-20%, in the case of fiberendoscopy and navigating interventions from one puncture it is 0%. It means that possibilities of conventional surgery from the mini- incision are quite limited, and with fiberendoscopy there are just a few of them.

In order to evaluate the opportunities existing for surgical interventions from mini- access, our colleague J.V. Mansurov suggested using the angle value opposite to the AOA.

From our point of view, it's a very important. It is true that when carrying out mini-access surgeries a special technique of operation the basic meaning acquires a special technique – endosurgical technique which limits of mobility of instruments within the access, but instruments should freely move within the operating area.

This statement gives occasion to work out corresponding term – endosurgical angle of operating action (AOAE). This angle is formed by the lines connecting the point of non-freedom of instrument and extreme points of accessibility area. Exemplify can serve the inner edges of narrow access segment at the point of entering into the widening part of operating area (Picture 3), or angle between the extreme states of bending parts of instruments. (Picture 28).

We should say that sometimes surgical techniques with elements of both traditional and endosurgical operating are used. In such situations the using of both criteria is necessary.

Limitations due to the tightness of access and difficulty of operation leads to the safety decrease, failure and iatrogeny risk. As it stands it's very important to fulfill the safety standards accepted for the conventional ways of surgery, which are carried out through the usage of high-quality instruments, equipment and gadgets, patients' evaluation and special much longer training of surgeons.

Taking into consideration existing risk of failures and complications, patients must be examined and prepared the way required for general anesthesia, wide access and conventional surgical intervention.

This statement is universal for all types of mini-access surgeries. Moreover, due to that fact, mini-access variants of operative intervention are more preferable for immediate diagnostic and surgical correction of possible consequent complications.

Evaluation of local surgical damage

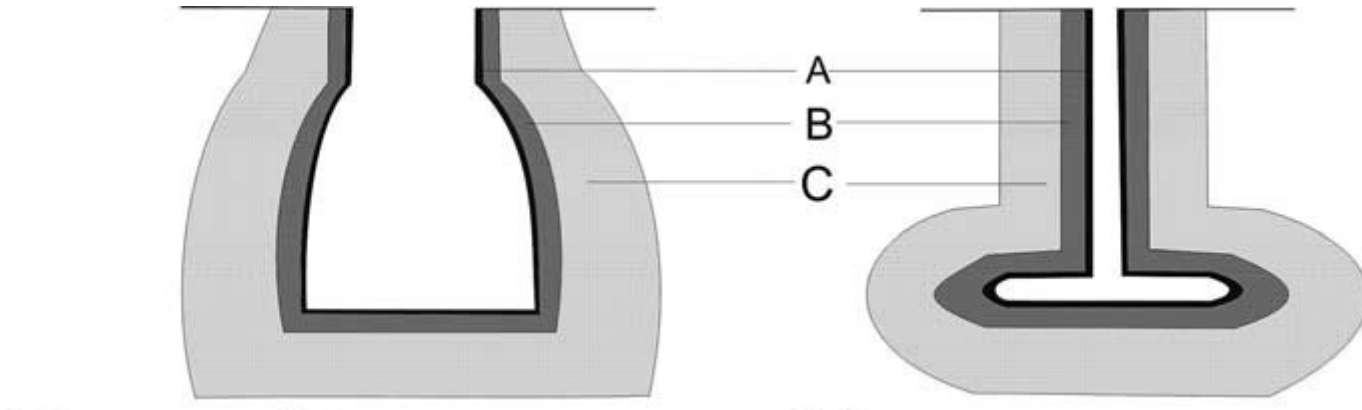
The characteristic feature of any surgical operation is the long-term tissue trauma in the process of its carrying out. There are particular consequences of damages of every singular organ and tissue type in the way of specific organ dysfunctions and systemic disorders. The usage of mini-access reduces the number of damaged organs. So in the post-operative period the intensity of complications also decreases.

But when estimating the surgical aggression another type of damages has a vital importance – non-specific local tissue damage (trauma).

Taking into consideration the law of conservation of energy, operation is a work! In that process the considerable part of physical efforts of team of surgeons, consequences of static pressure of mechanical devices and surgical equipment capacity are made for the local damage of tissues.

The process of trauma takes place continually and passes on several hours. After the operation the whole zone is under the influence of inflammatory-regenerative changes, their degree mostly depends on non-specific surgical aggression.

The surgical wound can be divided in to zones, in accordance with degree of changes.



Picture 4 *A- Necrotic zone*
B- Zone of contact damage
C- Zone of indirect damage

The fist zone A is a zone of fulguration. There is no living tissue in this area. The tissues are deprived of blood circulation, they are crashed or incised by the instruments or they have gone under the electro-coagulation and so on. The rejection, dead structures resumption and following tissue substitution, take place later.

Dead elements of tissue along side with the left debride are the favorable medium for appearing of wound infection.

Second zone B is a zone of injuries appeared as a result of direct contact with the instruments and hands of a surgeon. Part of cell structures get the irreversible changes and then die as a result of inadequate blood supply or infectious complications. Another part of cells is vital and it overcomes the damages.

The gross weight of tissues in both zones A and B and also the degree of their damage greatly predetermine the peculiarities of local wound process.

Tissue structures in zone C do not directly contact with hands of a surgeon and instruments. Their damage is brought up indirectly through the pressure. So the degree of their damage is much smaller. Nevertheless the degree and volume of trauma in this zone can vary greatly.

For example, for the local widening of abdominal cavity for small distance at the condition of muscle relaxation the insignificant efforts are necessary. They will bring only to the shifting of free lying organs. The trauma of surrounding structures doesn't happen.

Another situation can be seen while making the large surgical fields for conventional operation. The main criterion is the deformation necessity and enlargement of abdominal cavity volume. In this case the large physical efforts are necessary, and almost every organ and bloodstreams of abdominal cavity would be squeezed.

Possibly this fact can explain the widely used conventional surgical wisdom, that widening of access in the tight conditions will decrease the degree of surgical trauma, not the reverse. Actually, in this situation the widening of the incision makes the contact zone larger. The volume of abdominal cavity increases and the necessity of excess pressure doesn't exist any longer. As a result the zone C becomes multiple and its damage becomes less.

Pressure applied to the tissues with the help of retractors, material and hands of a surgeon, eventually leads to the vascular embarrassment and disturbances of microcirculation, venous drainage and even arterial circulation. More over the intensity of influence can spread differently, and the nisus of expressed tissue damage can form (close to the edges of retractors, bone structures).

The end of influence frees the vessels, brings about the stasis of local blood flow and tissue edema. The circle “compression-decompression” is repeated several times during the operation. Disturbances mentioned above have functional and reversible nature. But the mass of tissues involved in zone C can be several times larger than the zones of direct damage.

In the early post-operative period tissues from indirect contact zone become the center of post-traumatic disturbances, able to give rise to the functional dysfunctions. Manifestation of the latter depends on whole mass of tissues, intensity and length of damaging exposure.

A part of systemic malfunctions can also be determined by other mechanisms of damage, which in their turn are determined by the volume and degree of local tissue trauma (limits of diaphragm aptitude, post-operative enteroplegia).

The existence of relatively small mass of damage during the forming and liquidation of surgical access can explain the characteristic feature of mini-access operations – decrease in traumatic consequences and complications (pain, wound infection, herniae, pathological scars).

The decrease in the whole mass of tissues, damaged in the mini-invasive interventions (zones A, B, C) has even larger importance. It is many times less than in the conventional way of surgery. So, the consequences of surgical aggression are smaller.

Physical rehabilitation (replacement of physical activity, outer breathing function, blood circulation) takes place much quicker. For example, after laparoscopy through small access, it happens 2-4 times quicker than after wide laparotomy. After successful endoscopic papillotomy the complete physical recovery of a patient will happen dozen and even hundred times quicker than after transduodenal papillotomy through traditional access.

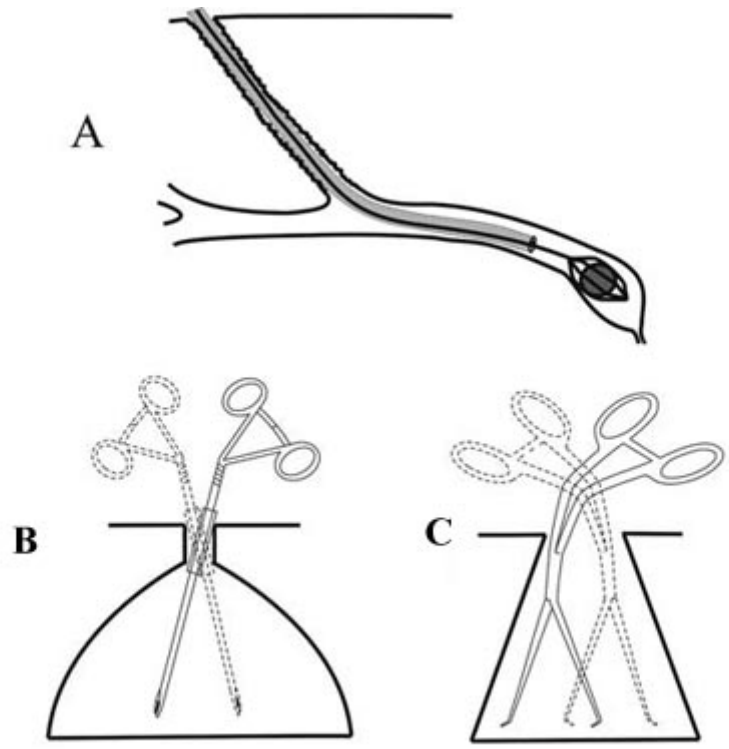
There is another situation with physiological adaptation of the organism to the functional loss after the operation. Extraction of gallbladder may lead to the change in conditions determining the peculiarities of functioning of digestive system organs. The main mechanisms of adaptation to the changed conditions of functioning and longevity of these processes do not depend on the method of operation.

The latter fact must be taken into consideration determining the time of disability and planning the whole program of functional rehabilitation.

The time of in-patient treatment and patient’s disability depends on time necessary for physical rehabilitation and returning to the work. After mini-invasive treatment it’s much shorter. E.g.: having positive conditions after laparoscopic cholecystectomy the patient may be released from the hospital in 1-2 days, and he can start working after 2 weeks.
At the same time the physiological adaptation of digestive system to the changed conditions (changed rhythm of bile production, failures to alkali in the period of digestive load, extra bile in the inter-digestive period, reflux-gastritis, duodenatice) May last for several weeks and even months. It’s almost the same time as after laparotomic variant of treatment.

Peculiarities of surgical instruments

The main types of instruments and gadgets used in mini-invasive interventions are the same as ones used in the open surgery (stabbers and cutters, dilators, needle- holders, forceps, clamps, probes and bougies, sewing gadgets, stents and endo-grafts, etc). Their mane difference is determined by the features of surgical access where they are used. (Picture 5)



Pic.5 main type of instruments for small access surgeries
A-catheter type
B- trocar type
C-traditional *type*

For operating through the narrow and bent accesses of retorts type, the flexible instruments of catheter type are used. For flask type access and hard endoscopy instruments of trocar type area more comfortable. For open interventions the traditional type instruments are mostly used, they are different from their analogues in shape and size.

A lot of variations of accesses used in endosurgery lead to the appearance of large number of the one type instruments but with different size.

For every particular operation instruments of the size which coincides with the parameters of particular access are necessary. At this condition strict unification and standardization is necessary.

Instruments and gadgets are usually marked with the length, diameter, horizontal section (French scale or Charier scale, Fr or Ch correspond the horizontal section in mm), gauge (G), angles of observation and controlled bending of the working end, capacity of air- filled elements and parameters of opening parts.

Every instrument requires its own volume and its own shape of free space. Taking into consideration the usage of small accesses and deep operating field, instruments for mini-invasive surgeries are longer than laparoscopic ones. In horizontal section these instruments must have smaller size that leads to the enlargement of the load to the axes and other elements, shown as the deformation.

More over such instruments appear to be more complicated and tend to break more. They are more difficult to clean and disinfect.

As a result, mini- invasive method gives higher requirements to the instruments: reliability of construction, usage of materials, and degree of precision of production, so all that increases their cost. Great attention is paid to the periods of work and cleaning, and establishing the period of exploitation. In order to guarantee the quality of the most complex and responsible steps of operations it is advisable to follow the principle of single usage of necessary instruments and gadgets.

The practice of the second using can low down the effectiveness of surgical treatment, lead to the failure and complications, be against the principles of infectious and immunological safeties.

Premises for conducting small access interventions

Premises for conducting small access surgeries must be equipped in accordance with their specialty and requirements for supporting the necessary sterile regime. The rooms must be under the set requirements, such as: square, volume, air ventilation, covering on the floor, ceiling and walls, protection against radiation, reliable earth, gas access, enough sockets for electrical appliances and emergency supply for electricity and gasses support.

Natural light through the windows is nit always preferable and purposeful. If so, the artificial coverings for the windows must exist.

The premises for the intervention must be equipped with narcosis – respiratory system, controlling and other appliances in accordance with set standards.

The effectiveness of using the rooms and equipment for the small access interventions depends on the spectrum of techniques and rate of usage.

At the conditions of great number of one type operations, it's advisable to have special rooms and equipment for each of them.

If there is no large number of patients, it's advisable to use more universal rooms and complex equipment with wide spectrum of usage.

The endosurgery for the manipulation through the natural ways and fistulas has sterile regime of dressing room and is not for the intervention with the help of other methods.

In addition to special appliances (operating table, endoscopic equipment , X-ray, US) it should be equipped with the appliances for antiseptic manipulations (sterile instruments and materials table, outer operating light, narcosis and controlling apparatuses, electrical aspirator, electric surgery of small capacity).

Small surgery for carrying out the less invasive surgeries (puncture drainage interventions from one puncture) in addition must have general surgical equipment (operating table, narcosis and controlling apparatuses, instruments and gadgets) and be ready for intervention in sterile conditions, using surgical linen and bordering the surgical field.

It must be inside the operating surgeon or not far from it. In the case of emergency of more invasive surgery the patient is transported to the appropriate room.

Operating room for complex interventions through puncture or small access must be equipped so, that in the case of necessity the surgeon can carry out the operation in traditional way.

The most comfortable devices are the X-ray transparent tables with the ability for bending and turning, with support for legs and the set of detachable gadgets.
Surgery must contain all the sterile instruments including ones for the traditional interventions.

Surgical light must provide the adequate lightning for the sure surgical actions on the outer layer and proceeding to the free access.

The capacity of surgical equipment must provide the opportunity for the traditional operations.

Special apparatuses are installed in this room stationary or in the portable variant, depending on specialty and profile.

It's a portable X-ray surgical apparatus with C-shaped stand, preferably with high frequency generator, digital camera, TV, monitor of high resolution, impulse regime and film memorizing, extra circling monitor.

US apparatus allows scanning in the present time regime, with high picture quality, possible B- regime and Doppler Effect. Besides the set of necessary diagnostic sensors the apparatus must be equipped with punctual sensors

Endo-video-surgical complex.

TV camera must be in accordance with its use. The camera with one receiving microchip (1 CCD) S-VHS is enough for the majority of endo-video surgeries. Complex operations may require 3CCD video cameras. In any case the camera must be enough sensitive, have protection from and the system of automatic adjusting of sensitivity according to the surrounding light.

While using the camera for the mini-invasive surgeries some special adapters are necessary. They will provide the camera attachment to the endoscopic devices.

Monitor must have the same resolution ability as the camera. It's preferable to have the screen of 20 inches size. It's better to have two monitors in different places for the surgeon and the assistant.

The lighter must coincide with the general level of requirements: level of lighting, power (usually not less than 200-250 Vat for halogen and xenon bulbs), automatically regulation of light according to the quality of picture.

The block must have the power enough to conduct certain procedures (40-60 VT for the flexible endoscopy, 150-300 Vat for operating through the wounds), have a necessary spectrum of electrosurgical action regime (mono- and bi-polar coagulation, cutting and non-contact coagulation), meet all the necessary standards of safety. It must also have hermetic double pedal of current governing with the sound and light indication, sensor of passive electrode and strict coincidence with indications on the board.

The use of modern electrosurgical apparatuses and their combinations with automatic adjustment of current parameters, bi-polar cutting regimes, argon amplified coagulation and melting of coagulating tissues are very effective.

Aspirator- irrigator must be enough productive and noiseless.

Insufflators for the endoscope through the wounds are different in their construction. First type must provide the carbon dioxide flow from the outer souse with the automatic regulation of its speed from 0 to 30 l/min, and regulated level of end pressure. Beforehand heating and moistening of the gas is preferable. Second type can be just a compressor sending the purifier air with the simple system of regulation the flow (valve with the manual management).

Special equipment (lasers, ultrasound and cryosurgical destructors, contact lithotripters, equipment for high frequency focused ultrasound ablation and so on) is extra installed in accordance with the range of applied procedures.

Because of great number of wires, joints and management devices special gadgets for their placement are important.

Robotic surgical systems are installed in the operating rooms of particular profile.

The interventions with the use of large sized equipment (CT, MRT) are usually conducted by the specialists of particular skills in the rooms where this equipment s is stationary installed. The rooms are sterile and specially equipped to conduct particular operations.

Special kinds of small access interventions

In modern clinical practice a great number of mini- invasive interventions and their modifications are used. They are almost impossible to describe in one paper.

It's more difficult to choose in every case the most effective and save method of treatment. It's necessary first of all to range the variety of existing and appearing small access techniques in appliance to the variety of clinical targets.

Using of theoretical basics makes the choice of rational treatment easier.

As an example, the evaluation of operating possibilities, limits, local and systemic consequences of some techniques is given in this paper.

Interventions through the natural holes and ways are widely used for interventions in the lumen of upper digestive system chambers, respiratory paths, outer hearing canal, and urinary tract, in the lumen of outer and inner female urinary-genital system, coloproctology.

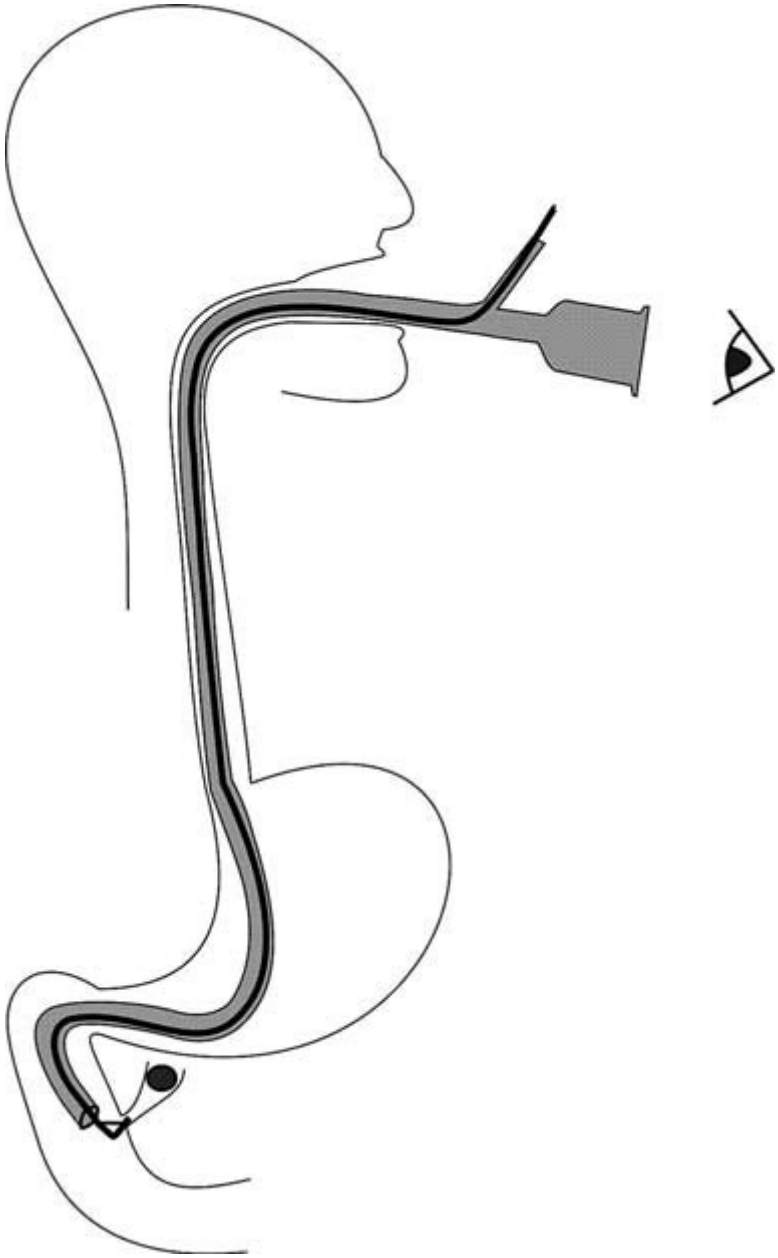
General features of these interventions can be described on the example of endoscopic papillotomy (papillosphincterotomy) offered by M. Classen and K. Kawai independently from each other in 1973. The main purpose of intervention is the resection of front wall of major duodenal papilla (MDP), for example to extract the stone from the general bile duct.

In this case the instruments must undergo the log and bent path into the lumen through the mouth, pharynx esophagus and stomach. It's not an easy task, requiring good orientation and precise control of movement in the lumen of mentioned organs.

The way to observe the operation is manual fiber-optic endoscopy.

The preparing for this intervention, as all other ones, consists of general and special actions. If necessary the correction of systemic dysfunctions and concomitant diseases is prescribed, starvation and stomach relies before the surgery, clearing the bowels, enema and gallbladder cleaning is done.

Before the surgery in order to relies pain and minimize peristaltic contractions, pre- medication is done, including sedatives, painkillers and spasmolytics.



Picture 6. Endoscopic papillotomy

The way of instruments movement is along the organs that have quite tough mucous covering with sub mucous layer that in some degree protects the tissues from injury and infections. Nevertheless carrying out such interventions requires the fulfillment of all requirements of infection safeties. It includes compulsory disinfection of every apparatuses and gadgets, using of sterile instruments, masques and gloves, special cleaning of the rooms.

Such a long and bent access with relatively small horizontal section excludes the possibility of straight observing of operating zone and of using the hard endoscopes with lenses. Fiber optic gives the picture with less, but quite enough to diagnose and operate.

Special fiber-duoeno scopes are used for endoscope papillotomy. They have enough length, side optic, appropriate manipulation canal and mechanism of adjustment the instruments inside it. (Picture 6)
Picture 6 Endoscope papillotomy.

The access to the stone comes through the lumen of manipulating canal, that has relatively small section (2-4 mm) and considerable length. In most cases the depth of manipulation is more than 1000 mm. Angel of classical manipulations in this conditions is 0 and the general technique is not possible.

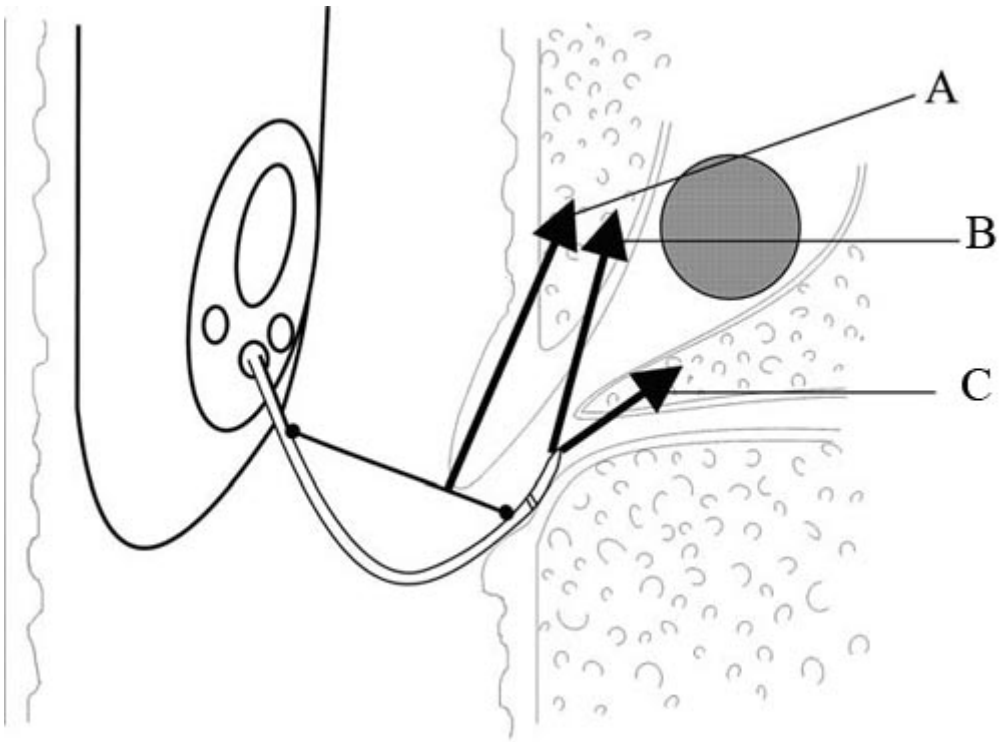
In the duodenum lumen the free volume is created by air insufflations and its' walls straightening. It's not quite stable but much larger than the manipulation canal lumen. As a result there is an appearance of inner operating space and freedom of movement for instruments with certain angle (endosurgical) of operating action.

Formed in such a way angle looks like retort.

The axe of operating action is a curve line of a very complex shape. The summed number of curves is more than 180 degrees. On the level of, MDP the axe is curved at the sharp angle on the short segment, it makes manipulation much more difficult.

The incision of the MDP wall is usually made with the help of papillotomas that has sliding out and distorting active electro surgical cutting instrument. This step is the most important element of intervention, because MDP is a functionally active organ, providing co-acting of several aggressive media: bowels content and duodenal content, bile and pancreatic secretion. The fact that surgical access to the stone of choledoch requires the destruction of the wall is the biggest disadvantage of this technique in general.

The appearance of complications (Picture 7) is influenced by a range of circumstances.



Picture 7 Types of retro duodenal perforations

A Through the zone of merging of common bile duct and duodenum.
B. through the choledoch wall
C. through the wall of pancreatic (Wirsung's) duct

Firstly, flexible instruments of long size are used. It complicates the tactile control over the physical efforts. Secondly, for inserting the instrument from manipulation canal of duodenoscope into the choledoch it's necessary to overcome sharp angle curve. The way into the Wirsung's duct is gentler, and it's easier for papillotom to get there. Thirdly, the tip of gentle and flexible papillotom in free position appears to be hard and tens at work. If there are any complications the manipulation of hard tip can bring the MDP injury and complications (cholangitis, pancreatitis, retroduodenal perforation). More over the active electrode of papillotome may be in the bile. At that point the zone of electrical injury through the liquid can be uncontrollable.

To avoid complications the papillotome is inserted gently and slowly according to the visual picture in the eye of fiberduodenoscope, then it's promoted to the MDP canal. The following way is observed with X-ray television, contrasting the ducts structures of MDP.

After installation of papillotome 11-12 hours, electro incision of front wall of MDP along the longitudinal crease of mucous coating is done, cutting and coagulation is intermittent.

Necessary length of incision is determined paying attention to the anatomical peculiarities (localization of MDP, its size, form and length of shared wall with duodenum, relations of choledoch and Wirsung's duct) and stones size.

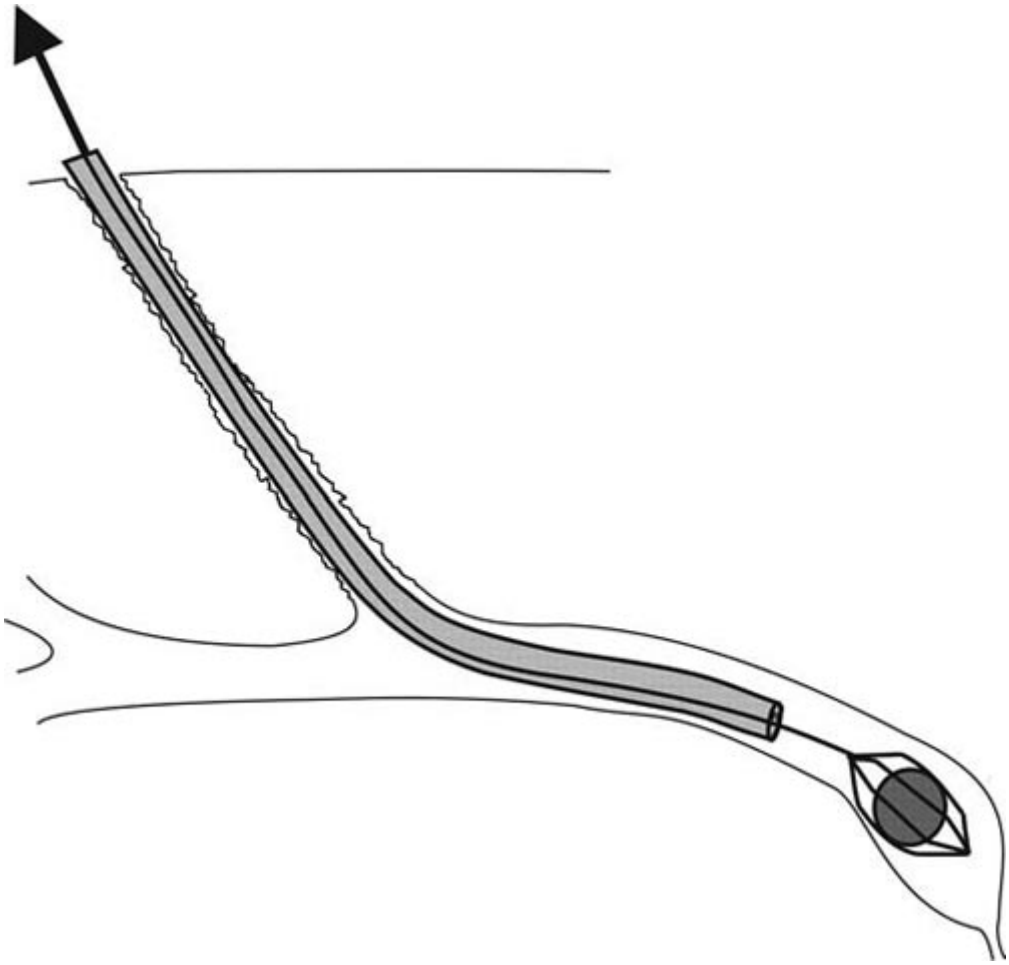
Correct papillotomy in most cases deprives patients from stones without post- operative sufferings, scars and extra cost of treatment. Endoscopic papillotomy surgical injury zone is limited to the front wall of MDP, and the injured tissues mass is 1-2 gr, which is thousand times less than at transabdominal variant of the same operation.

This can easily explain the fact that endoscopic papillotomy aside its disadvantages(extra expenses for the instruments and devices, complexity of manipulation at such depth and in such small spaces, risk of severe complications, inevitable destruction of sphincter apparatus and biliar tract autonomy loss) supplants the trans abdominal interventions of the same targets.

Fistula access interventions. They are made less often.

Endobiliar interventions, done through outer bile fistulas. The evidences for its use are the presence of surgically removable pathology in biliary tract (left concrements and strictures) and interfistula access into the zone of pathological changes after undergone abdominal surgeries (transcuteneous trans hepatic cholangiostomy, outer drainage of hepatocholedoch, cholecystotomy).

As an example we can name removal of the left stone of choledoch with the help of wire scavenger of Dormina type through the fistula canal. (Picture 8)



Picture 8. Removal of the left stone from the choledoch through the outer bile fistula.
The target of intervention is to relieve the patient from the MDP apparatuses destruction or second abdominal operation, using the temporal outer fistula as a surgical access.

The walls of the scarry part of fistula are the thin layer of granulation tissues. The lumen is infected that requires the careful and protective manipulations.

Around the fistula canal there are postoperative adhesions between the organs of sub hepatic space, which depends on the technique of earlier operation and features of drainage tube.

The conventional surgical interventions through the laparoscopic access form the durable adhesions in the majority of patients in 3 weeks time.

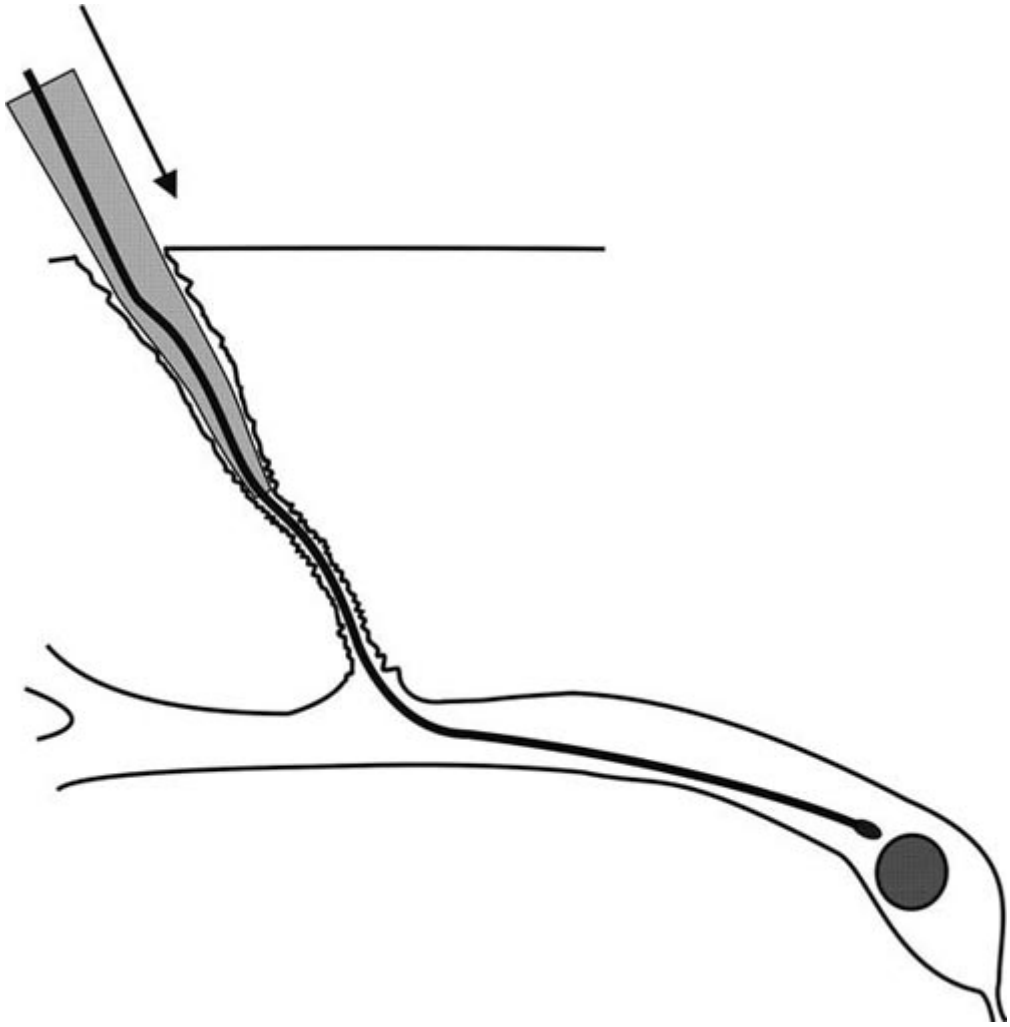
In geriatric patients and patients with sever accompanying disorders (diabetes mellitus, HIV, long-term steroid therapy, immunodepressants use etc.) the period of forming the adhesions is 4-5 weeks and more.

After laparoscopic operations the adhesions are usually formed slowly, their durability is less. Because of inappropriate drainage cutting off from the free surface of abdominal cavity, laparotoscopic interventions are seldom finished with outer drainage of bile ducts, more over with the use of forming canals for trans fistula procedures.

The lumen of the fistula canal is supported with drainage. After removal of drainage tube the canal quickly deforms and loosens because of layers shifting and retraction of new scars. That's why it's removed just before the manipulating beforehand adjusting the string (guide) in to the ducts through its lumen.

The diameter of such a canal us usually 5-6 mm, that predisposes the outer parameters of devices used for interfistula manipulations.

The fistulas of smaller diameter, after forming the stable wall, are widened step by step under the fluoroscopic TV control with the hollow calibrators along the directing guide.9 Picture 9)



Picture 9. widening of inter fistula access with the calibrator (bougie) along the guide.

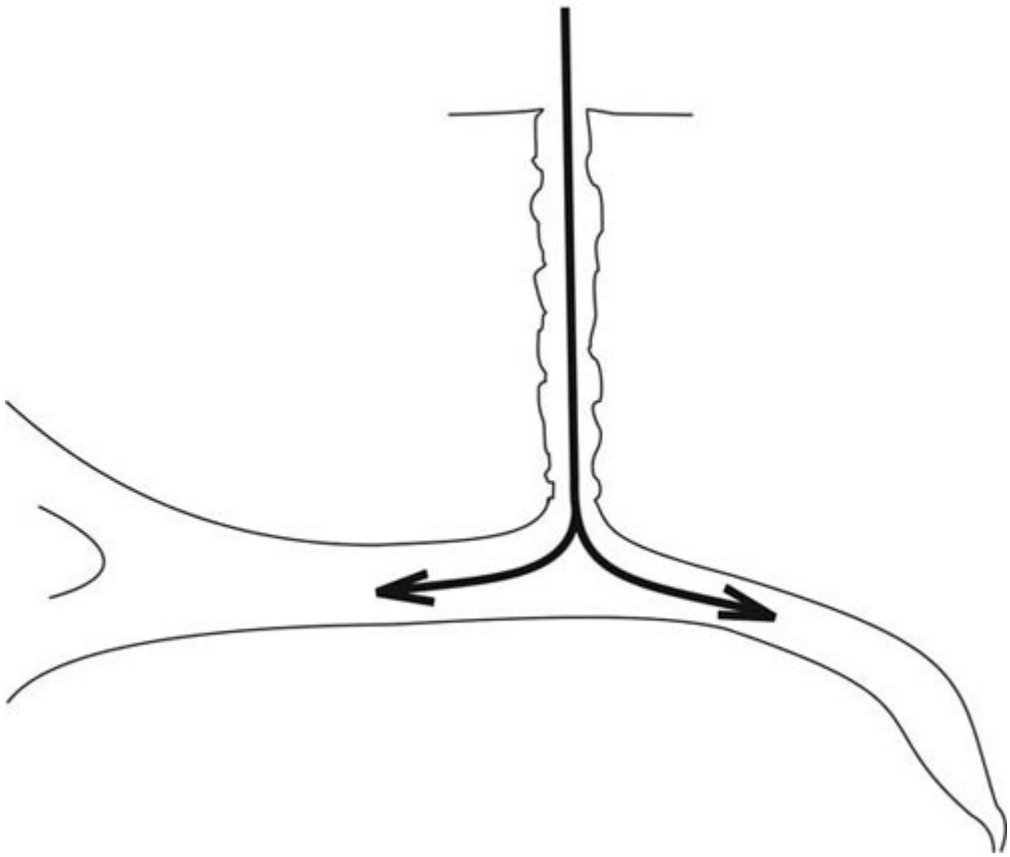
The lumen of the fistula canal is widened 1-2 rates of Sharer scale in every 2 days. So the diameter of drainage left in the fistula canal is widened too.

In order to avoid the rupture and scratches on the walls of fistula canal and bile ducts, the tips of calibrators should be conically sharpened. The bougies themselves should be made of soft thermoplastic materials.

The depth of such an access from the outer hole up to the stone in the distal chamber of common bile duct is 10-20 cm that is 10 times less than in the case of peroral access to the same zone.

T-type drainage forms the scarry canal connected with bile duct under the angle of 90 degrees and the radius of curve 1-2 sm. It's a rather prominent curve, but the limits imposed by it are much less strict than in the case of peroral trans pillar access to the stone of choledoch.
The sum of curves is even less. That's why to manipulate through the fistula access is much easier.

There are two axises of operating action. (Picture 10) One of them goes to the distal chamber of the bile duct (the most frequent place of stone localization), another – to the hepatic duct.



Picture 10. Access to the bile ducts through the outer bile fistula, formed with the help of T-shaped drainage. Y- the axis of operating action.

The prominent axis curve is overcome with the help of special devices with controlled working tip- Burhenne probe, manipulating fiber choledochoscope.

The Burhenne probe is inserted into the zone under the TV control. For this the biliary tract and fistula are contrasted beforehand. Fiber choledochoscope has its own optic but for straightening out the lumen and creation of transparent medium, the consistent infusion of sterile washing liquid under the controlled pressure is necessary.

Later through the manipulating canals of the probe or fiber choledochoscope the necessary instruments are inserted and brought up to the stone that excludes almost t all the fistula walls trauma.

At the process of manipulating under the fluoroscopic TV control the axis of observation is almost perpendicular to the axis of operating action. At the process of inter fistula fiber choledochoscopy they are parallel.

The free operating space for the manipulating of instruments is presented with the probe or choledochoscope manipulating canal and the lumen of bile duct in the zone of intervention. Its volume is not large and its number is only some cm.

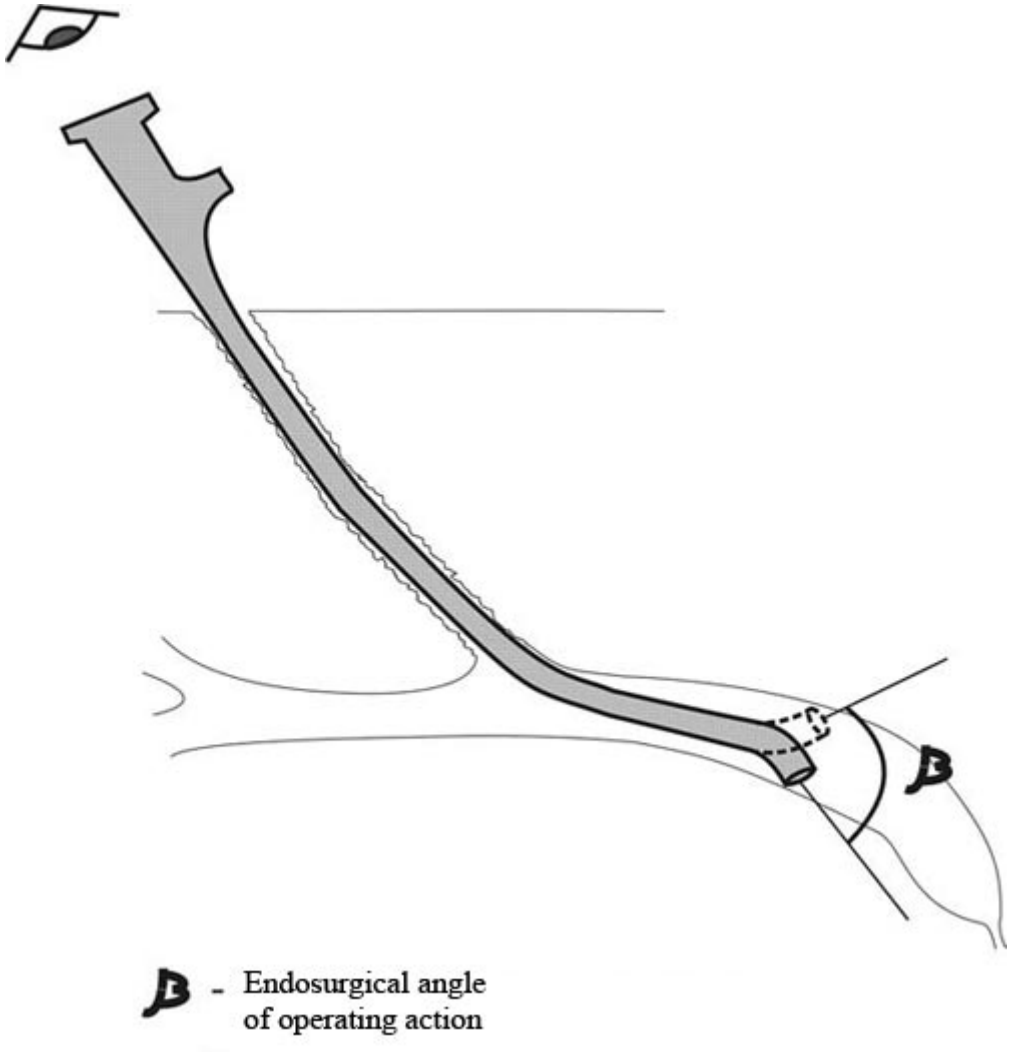
The shape of operating space is the long and narrow cylindric canal of 2-3 cm in diameter with a little widening in the zone of operating. The traditional angle of operating is 0 degrees; cavascopic angle in the ducts of 10 cm, is usually 10-45 degrees.

In such conditions narrow and flexible instruments are necessary; their parameters should coincide with the size and shape of operating space. In the closed position they must freely go through the lumen of operating canal. They should not have hard elements, not able to go through the curve of 90 degrees.

The length of instruments is several times shorter than of the instruments used UN peroral endoscopy. It gives back to the surgeon a part of tactile feelings.

The working part of wire scavenger for the stone taking should be appropriate to the stone size and the lumen in which the stone is located. The probe for the contact lithotripsy may have cilindric form along the whole length.

Management of the working tip of the instrument is done directing the Burhenne probe or the choledochoscpe into the particular side. (Picture 11).



Picture 11. Flexible instruments management.
Endosurgical angle of operating action.

Concrement of small size may be taken and extracted as a whole. Larger stones undergo the contact lithotripsy (mechanical crashing with special wire loop, laser lithotripsy, shock- wave lithotripsy) and extracted part by part.

After the stone removal as after any other surgery the control revision of fistula and duct system is conducted.

Fistula closing is done step by step. First the healing of inner hole of bile fistula is achieved. For that the thin catheter is inserted into the fistula canal through the guide, it doesn't reach the bile duct lumen 1-2 cm. and then the catheter is attached to the skin.

This type of intervention with the outer fistula present seems to be more preferable than theendoscopic papilotomy or laparotomy.

In the comparison with endoscopic peroral variant intrafistula removal gives symplier, shorter and much less curved access witch doesn't touch MDP – very functionally important and trauma sensitive organ.

The mass of injured tissues and the degree of injury are not large; the same as in peroral endoscopy, but the risk of serious complications and consequences – taking into consideration the unnecessity to destruct the MDP is less.

In comparison with laparotomic interventions the inter fistula removal of the left stone from the choledoch is accompanied by the trauma of ever slight mass of tissues.

Thus, in case of adequate inter fistula access to the bile ducts, necessary equipment and surgeon experience; this type of intervention has advantages over the traditional types.

Interventions through the wounds

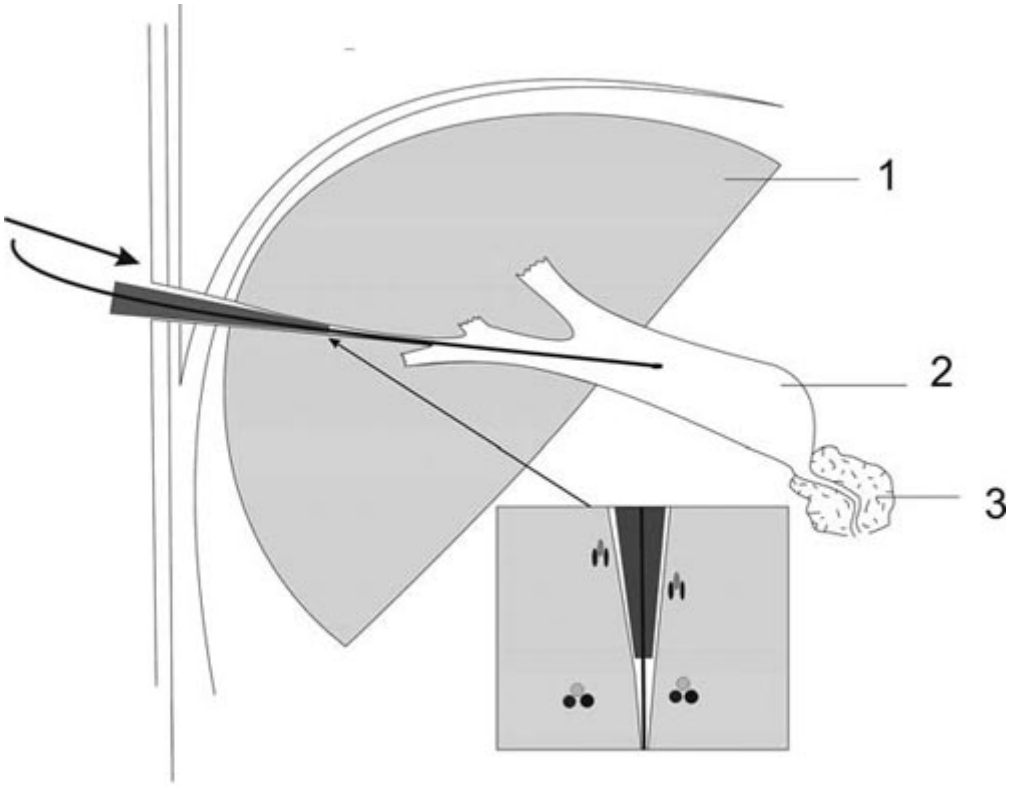
Puncture interventions. The main feature of puncture access for small access surgeries is the hermetic quality of wound canal, witch is important to save from the beginning to the end of operation. Following of this rule is necessary for the opportunity itself of carrying out many puncture surgical techniques and complications protection.

The sharp point or the bladder of instrument should be on its working part and be much smaller than the vertical section of main part of the instrument.

After the removal of the instrument the wound almost loses its lumen because of the tissues retraction and layers shifting. In the small access surgery the lumen is supported with the special dilators of tube type (metal or plastic trocars and catheters etc.) They must be along the wound canal up to the operating object and must be tightly taken in by the surrounding tissues.

Two main types of installation of such devises are used – along the guide or along the needle (stylet). In the first type the puncture is done by the special needle with mandrin. After the successful puncture the mandarin is changed for the guide. The needle is extracted, while the guide is left in the place. Then the dilator is inserted along the guide. As a rule it's a flexible catheter with working surface of conical form, main part whose outer diameter is 1-2 № Fr more than the diameter of already taken away needle.

Going along the guide the catheter spreads, moves apart and pushes together surrounding tissues. As a result the catheter is hermetically surrounded by the tissues, and small vessels and bile capillaries in the zone of the wound canal are pushed together. It helps to give extra safeties and hermetic quality of the wound canal- catheter system. (Picture 12)



Picture 12. Transcutaneous trans hepatic access into the bile ducts through the incision.

1. *liver*
2. *bile ducts*
3. *tumor*

The technique of installing the dilator along the needle and the stylet differs from others in a way that the dilator is installed beforehand on the incision instrument and together they are inserted into the place.

Set dilator makes the wound into the port for inserting and changing the instruments.

At that point wound canal tissues are extra protected from trauma and infection.

The only limit is the usage of instruments with strictly given parameters. In order to help to choose the instrument and device the marking is used.

One puncture technique

This technique refers to one incision used as an access itself for the particular manipulation or its part in the way it's done in case of trans- coetaneous and trans- hepatic cholanangiostomy.

The main target of such interventions is to provide the outer flow of bile from blocked chamber of ducts system.

As an access the trans hepatic puncture of one of blocked and dilated bile ducts of right liver lobe under the US examination is more often used. To get the target the puncture nozzles for the diagnostic sensors or special puncture sensors are used. The advantage of the latest is that they give possibility to see on the monitor the direction in which the needle will go, and they have fewer limits while choosing this direction.

The final characteristics of one puncture access have a lot in common with inter fistula accesses (width, length of access, familiar ways to observe the zone of operating action, characteristics of operating space).

There is a range of essential differences.

Access depth is not large and is comparable with interfistula one. But its essential part is in the wound canal. More over the length of wound part access is predominated. This access is not present originally and must be created by surgical procedures. At first the point of incision and its way in the tissues up to the digestive duct is established. It's done in order to avoid contact with large vessels. Then, the scheme of instruments manupulating in the duct system taking into consideration the number of curves and bents is established, paying attention to the control criteria of every step correct fulfillment.

The importance of making initial way and necessity to move according to the markers, using of special devices included, gave these kinds of interventions the name navigational, as an analogue of sling. (Lat: "navigation" – sailing).

The incision is usually done with a sharp end of scalpel, its size a little bit larger than necessary for the needle installation.

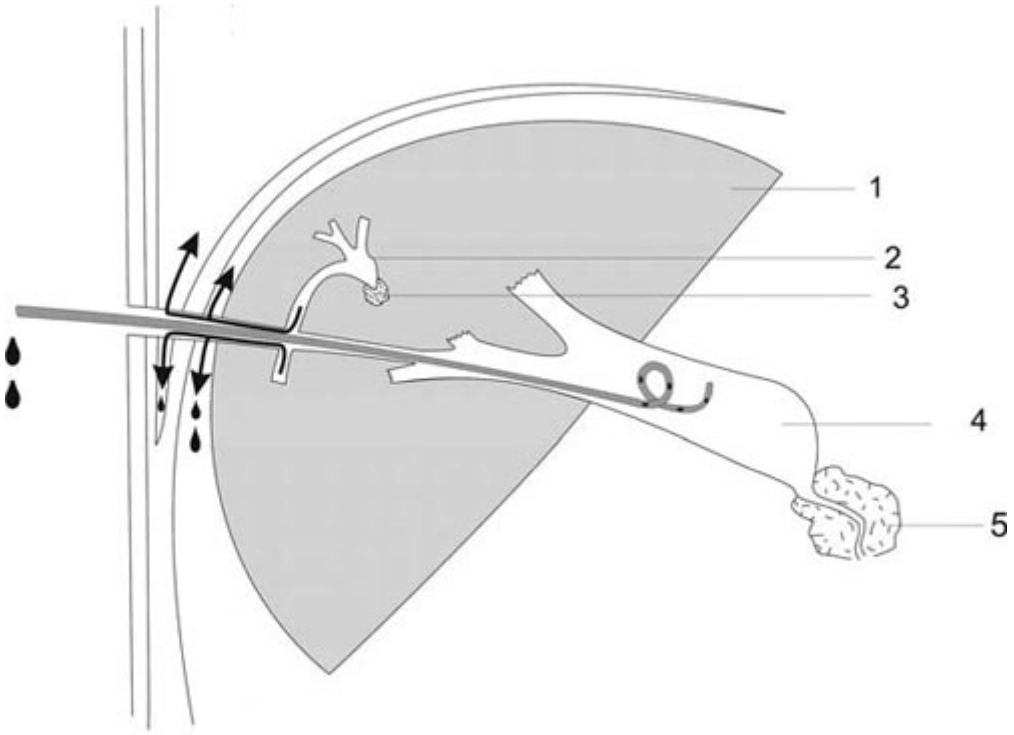
For puncture special needles are used, whose structure predisposes the way of the following catheter installation in the bile ducts (along the guide, stylet-catheter, needle with removable etc). While using US navigation these needles can have extra curing for better vision on the screen (special micro surface of the needle or mandrin.

The incision is usually made at breathing in through the lumen of thicker needle which is beforehand inserted into the abdominal cavity through all layers in the necessary direction. After successfully done puncture there is an opportunity to fill the biliar tract with fluoro-contrasting solution and visualize it on the roentgeosurgical apparatuses.

In many cases the location of outer puncture is in the intercostals space (8-10), and created in such a way wound canal has no walls and can be interrupted in the pleura sinuses and under diaphragm space, that requires special attention to the hermetic quality. In the other case air can come to the pleural cavity with creation of pneumothorax, blood and bile, sometimes infected, can come to the under diaphragm space and free abdominal cavity.

Air tightness of the wound canal is provided with tight surrounding of inserted instruments and tubes by surrounding tissues. Tissue distortion effect is reached with the use of flexible hollow catheters with conical narrowing tip. The catheters are installed in such a way that side holes of catheters are only inside the ducts lumen. The correctness of location is notified with a help of fluoro contrast markers on the catheter walls. Wound canal in the liver up to the entrance to the lumen of punctured duct goes through small duct structures, blood vessels and bile capillaries. Correctly installed catheter is hermetically tighten by liver tissue and provides the effective decompression of the whole system. At the same time there is no blood and bile dropping alongside the wound canal.

Because of high fluidity of normal bile theoretically it's enough to insert catheter having capillary inner lumen in order to decrease the inner lumen pressure in bile ducts. The exception can be the situation when biliar tract is blocked on some levels, for example with tumor process (Picture 13)



Picture 13. blocked segments damage risk in the case of multi- leveled ducts blocked

1. *liver*
2. *blocked bile ducts*
3. *metastasis*
4. *decompression zone*
5. *edema*

In this case wound canal can go through the blocked segment of parenchyma, which didn't get the bile outflow through catheter lumen. Then bile will go to the wound canal through damaged tiny bile ducts and then further along the catheter into the abdominal cavity. That's why presence of many metastasis dividing biliar tract system into segments can be a counter indication for transcutaneous puncture techniques.

One more problem is connected with changes in bile viscosity and structure. At some pathological processes bile can become vicious or some particles can be present in it: fibrin membrane, cholesterol crystals, pigments meal, epithelium, and tissue detritus.

At the beginning all these particles flow out together with bile along the catheter with capillary inner lumen. But with the situation can dramatically change. Sticking to the walls of catheter the particles makes its lumen smaller. The bile outflow along the catheter is smaller, major part of included particles are left in the ducts becoming a very profitable medium for pathogenic flora development. Bile becomes more vicious and consists of more extra particles. Then catheter's lumen is blocked. Mechanical jaundice and liver dysfunction are the relapse of the process. Cholangitis becomes obturated. Not having entrance bile starts going along the wound canal but not through the catheter. To avoid such situations it's more preferable to use devices that can give not only decompression but drainage of bile together with included particles. That's why in biliar surgery for outer trans hepatic bile outflow it's better to use drainages with inner lumen not less than 1, 5-2, 0 mm and extra side holes on the distal tip.

Procedure of dilatation of puncture access until the forming the necessary lumen can be done at one time with the help of step by step boogieing by hollow bougies of growing diameter along the guide. The widening of liver parenchyma happens, more dense tube structures near the puncture canal are pulled

apart by the blunt tip. As a result of breathing, body movements, especially at coughing organs taking part in the access forming are shifted, and the access length is changed. At some point the drainage tip can be out of the duct lumen and even the wound canal. Next moment because of its elasticity it'll straighten up in the abdominal cavity.

In order to prevent such situations only special catheters with mechanism of fixation in the duct lumen and extra devices (air balloons, bending and spiral elements, extra length catheters, harder guide in the catheter etc.) should be used.

During the last step of forming the access a special thin walled catheter is installed in the wound canal from the skin to the entrance to the ducts, catheter is being fixed in this location.

Later this catheter will support the wound canal lumen and server as a barrier that forms walls of access and protect surrounding tissues from operating damage and infection.

The presence of ascites will bring the abdominal complications of trans cutaneous trans hepatic procedures because the ascetic liquid will interfere with the forming of broadening adhesions.

Evaluating the features of trans cutaneous trans hepatic interventions in comparison with inter fistula ones we can't help mentioning their similarities and differences.

Their surgical opportunities are quite comparable because of similarities in the parameters of surgical accesses.

There are some differences too. Operating action axis has only slight curves of small angles while manipulating in the lower chambers of biliar tract through trans cutaneous trans hepatic accesses. It makes easier the following procedures such as recanalization and stenting of bile ducts. The major part of procedures can be done in one step that fastens the treatment considerably.

From other side trans cutaneous trans hepatic access can be always transformed into trans fistula one, for example, creating the way for periodical exchange of endobiliar grafts. For this it's necessary to leave the particular catheter in the wound canal until the scar walls forming.

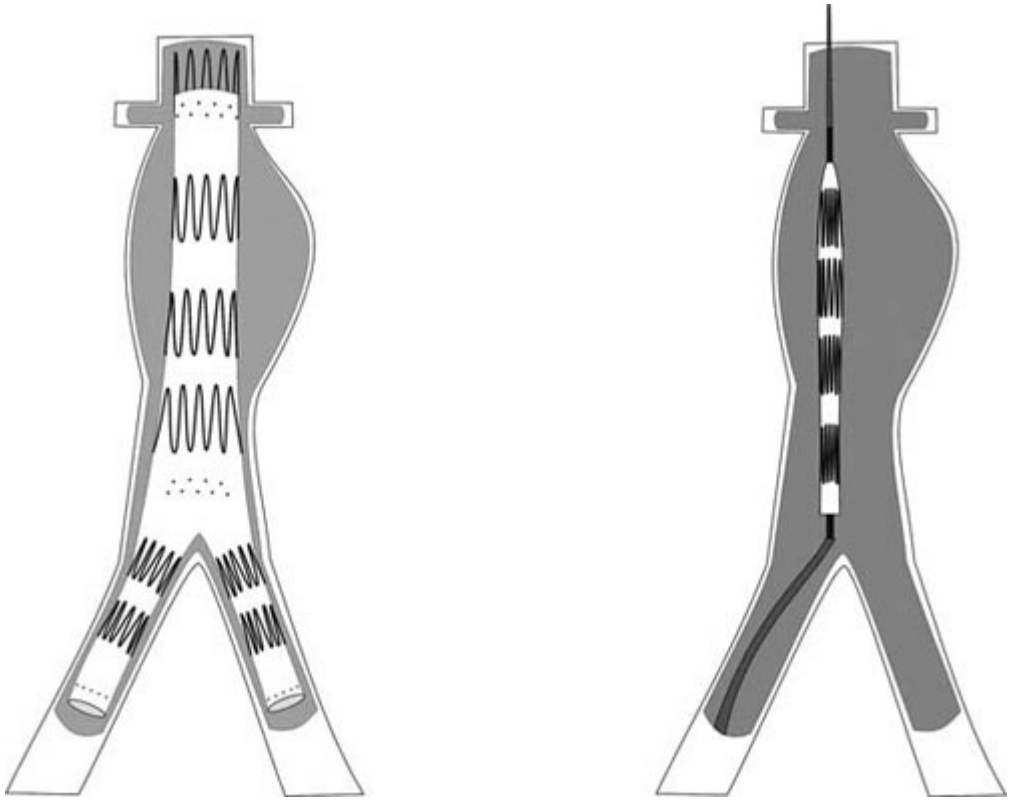
At the same time puncture interventions are associated with the higher surgical aggression and operating risk. The general mass of damaged tissues and degree of damage are really small. The greatest danger is damage of tissues and organs on the way of wound canal (pleura, lung edge, diaphragm, peritoneum, liver, blood vessels, and bile ducts).

As a result these interventions are in the group of reserve – it means that they are done when there are no conditions for successful per oral or trans fistula operations, but wide laparotomy is still avoidable.

The characteristic features of fluoroscopic endovascular interventions are other correlations between the lengths of wound and inter lumen part of access, form, volume and other characteristics of operating space (blood presence, direction and speed of blood flow).

The important step in the process of creation of such interventions was the suggestion of S.I. Seldinger 1957) to form puncture access into the vessels along the directing guide.

Fluoroscopic endovascular prosthetics of abdominal aneurysm requires the installation and fixing of special net construction in the zone of changes. (Picture 14)



Picture 14 Endovascular prosthetics of abdominal aneurysm.

Later the net material of the graft and the surrounding space will be filled with thrombus masses and inner surface of prosthetic will be covered by endothelial cells. Thus a new wall of aorta will be formed.

The first step of intervention is the forming of access through the femoral artery. Femoral artery is located close to the skin and it can be punctured with anatomical orients and feelings of surgeons.

Wound part of access is formed according to the Seldinger, paying attention to the hermetic quality as the arterial pressure is much higher than in surrounding tissues and air. Guide and the catheter are directed proximally in to the side of abdominal aorta.

The operating space looking like a narrow deep bottle appears. Through its entrance it's necessary to install quite a voluble device. It must be inserted in a closed position inside a special gadget of delivery, or in the prosthetics construction there must be elements providing the transporting the instrument in the closed state and transformation of it into the working state when necessary.

The main step of intervention is carried out in the aorta lumen which has a relatively free volume. From one side it makes the endosurgical angle of operating action larger and widens the possible manipulations, from the other side it gives birth to the extra difficulties. Flexible instruments in the wide space lose the base and are ore difficult to manage. A lot of things are taken into consideration. They are arterial branches, direction and intensity of blood flow, curves o instruments and devices, their elements and others. For the observing the flow of operation the roentgenoscopic TV devices with high resolution are used.

The endoprosthesis itself is a highly technological device. Material from which it's made of should provide easy sliding and safe work of the whole construction, be biologically inert and "implanted" into surrounding tissues, it should not create conditions for infection, should not resorpt and should stay mechanically stable, should not have teratogenic action, should prevent traumbus forming on the inner surface and so on.

Clinical effectiveness of fluoroscopic endovascular prosthetics are in many cases correlated with the results of traditional interventions from the open access. At the same time the mass of damaged tissues at the fluoroscopic variant of operation is only several grams that is thousand times less that in the classical case. It covers any expenses for the extra equipment, materials and specialists training.

Video laparoscopic operations can be a very good example of modern opportunities of multiple puncture technique.

The basis of video laparoscopic cholecystectomy was done by Ph. Mouret, who first conducted this operation in 1987.

The main steps of this operation are the following. Firstly with a help of special needle the abdominal cavity is punctured.

This step is done with very strict following of the safeties rules with a help of special needle with blunt mandrin protecting inner organs from damages.
Then the abdominal cavity is straightened up by the gas flow.

Manageable pneumaperitoneum raises the front abdominal wall forming the free space over the organs. This space is used for operation.

Then in some points of abdominal cavity some troacators are installed punctually, after removal of stylets the troacators become ports for hermetic inserting and changing of the instruments.

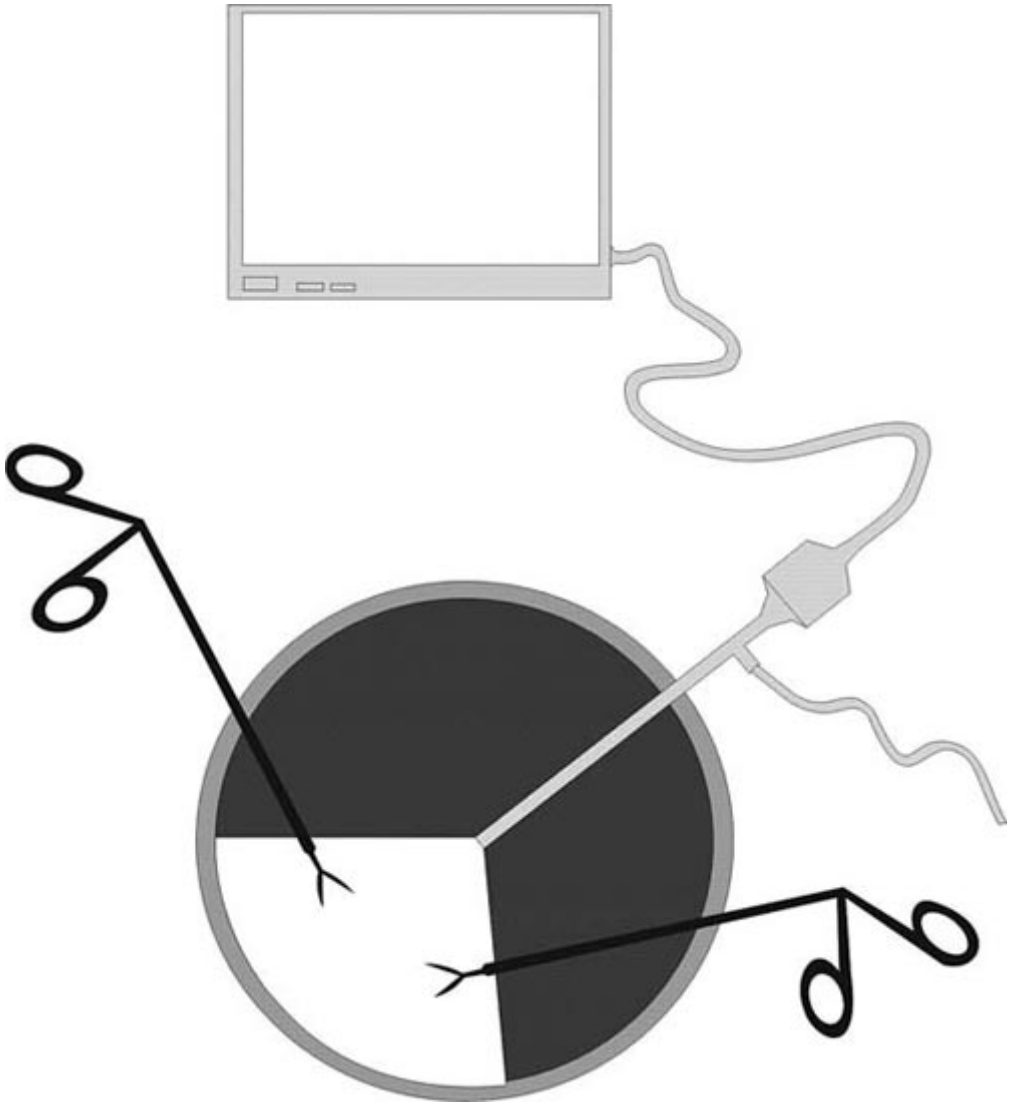
To make the selection easier the instruments are marked (5 mm, 10 mm, 22 mm, 13 mm) according to the troacar lumens. In order to use thinner instruments through the wider port hermetically, adapters are used having the correlating marking (e.g. 5/10 mm).

But not the whole space created by pneumoperitoneum is necessary for operating. For example, for cholecystectomy only a small part of it is used, this part is located between the abdominal wall puncture and gallbladder.

For this space to be enough it's necessary to put the punctures away from each other and to shift them from the gallbladder. At that point the space area is enlarged and the access depth is enlarged too.

The wound part of the access is not united and consists of several rather far away punctures. The discretion of access becomes one of the principal decisions put into the basis of laparoscopic surgery and similar techniques. Its appliance allowed to considerably enlarge the inner surface of access and to bring the mini-invasive surgery the traditional opportunities.

Through one of the trocar the laparoscope is inserted, through which the observation is conducted. Further the picture is transmitted to the video camera and the monitor. The axis of observation becomes enough complicated. It's represented by the segments of the curved line on the level of electric devices, interrupted as the optic way of vision transmission. (Picture 15)

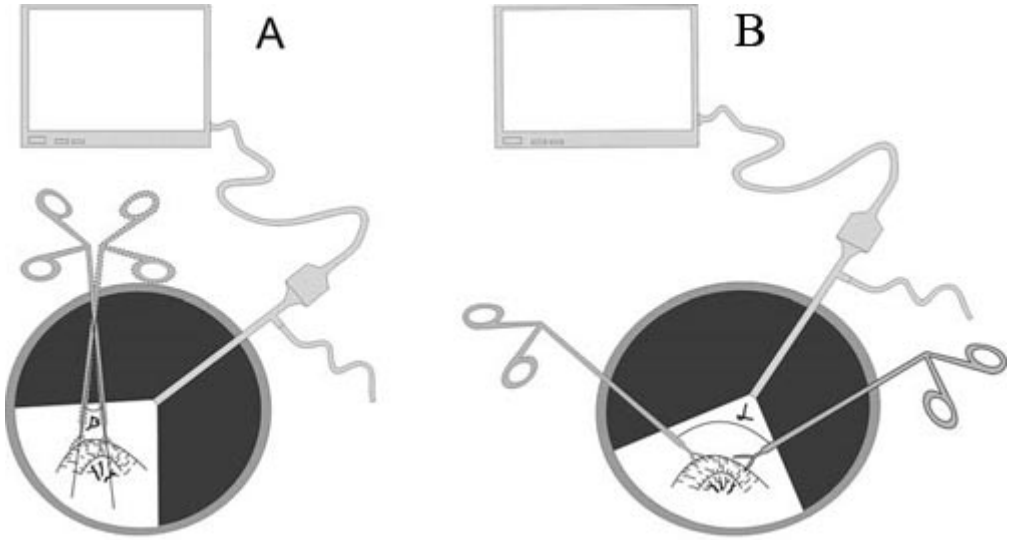


Picture 15 Video laparoscopic operations.

Video laparoscopic manipulation was quite difficult before the appearance of special equipment for the endovideosurgery. The surgeon had to hold the laparoscope by one hand. With the help of another hand he was trying to manipulate in the abdominal cavity. The assistance saw nothing and was of no help at all.

The opportunity to have monitored endovideo observation helped the surgeon and became one more significant element of the whole technique. The surgeon got the opportunity to stand up straight and to operate with the help of both hands. His assistants got the opportunity to see the zone of operating and to help effectively.

While using several accesses the angles of operating action of different type can appear. (Picture 16)



Picture 16 Video laparoscopic interventions from several puncture.
Angles of operating action.

A. *For every single instrument.*
B. *For the integrated using of two instruments.*

Every single instrument has an opportunity to work separately. Its own axis of operating action appears. But the opportunities of such operation are quite limited. The classical angle of operating action on the gallbladder is 0 degrees, and the endo-surgical angle is relatively small. For example while manipulating on the elements of gallbladder neck from one puncture in the mesogastric area it's not more than 5-6 degrees.

Another situation is seen while using several punctures as one discrete surgical access. The quantity of classical angle of operating action becomes relevant to the conditions of open surgery from large access. Every instrument keeps its surgical angle. The opportunities become very considerable.

The most comfortable is the laparoscope with the curve of 30 degrees. It gives better opportunities for observation, even at such angles which are not accessible in the open surgery.

There are also some difficulties. The surgeon can see only the zone of operation and the working ends of instruments. Other chambers of abdominal cavity and parts of instruments are not seen. It hardens the requirements for the electro surgical instruments. They must not have any defects of isolating covering. The bare part of instrument can be a reason of unnoticed electro surgical burn if it touches the tissues in the unobserved zone.

Hemorrhage considerably interferes with the observation and laparoscopic surgery opportunities. To avoid the mistakes a surgeon must achieve thorough arrest of bleeding.

If there is bleeding and necessity to consider the interoperating loss of blood the surgeon must know the particularities and limits of laparoscopic revision.

From one point video laparoscopic picture enlarges the size of objects in the center of observation. That's why some drops of blood may seem to be a considerable bleeding.

From the other side the blood volume in the observing periphery seems to be smaller than in reality.

Blood flows into the deep chambers of abdominal cavity and disappears from the visual zone. It's closed by the momentum and the intestinal loops.

That's why at the end of operation besides the zone of operation the whole abdominal cavity with pockets and deep chambers should be inspected, cleaned and dried. The last step of operation is the removal of

pneumoperitoneum, drainage installation, removal of trocars and if necessary the sewing of abdominal wall puncture. Trauma from laparoscopic surgery is larger than from described above interventions through the natural accesses and fistulas. But it's still relatively small.

In video laparoscopic cholecystectomy in the zone of local damage there will be tissue parts in the point of abdominal wall puncture, peritoneum, gallbladder and surrounding tissues. Their mass is dozens times smaller than in open surgery from large access.

The zone of pressure on tissues can be even larger than in open operations. It covers the whole abdominal cavity, attached retroperitoneal structures and large veins (venous blood flow to the heart), even covers the thoracic organs (diaphragm shift, damage of its respiratory excursion and lung ventilation).

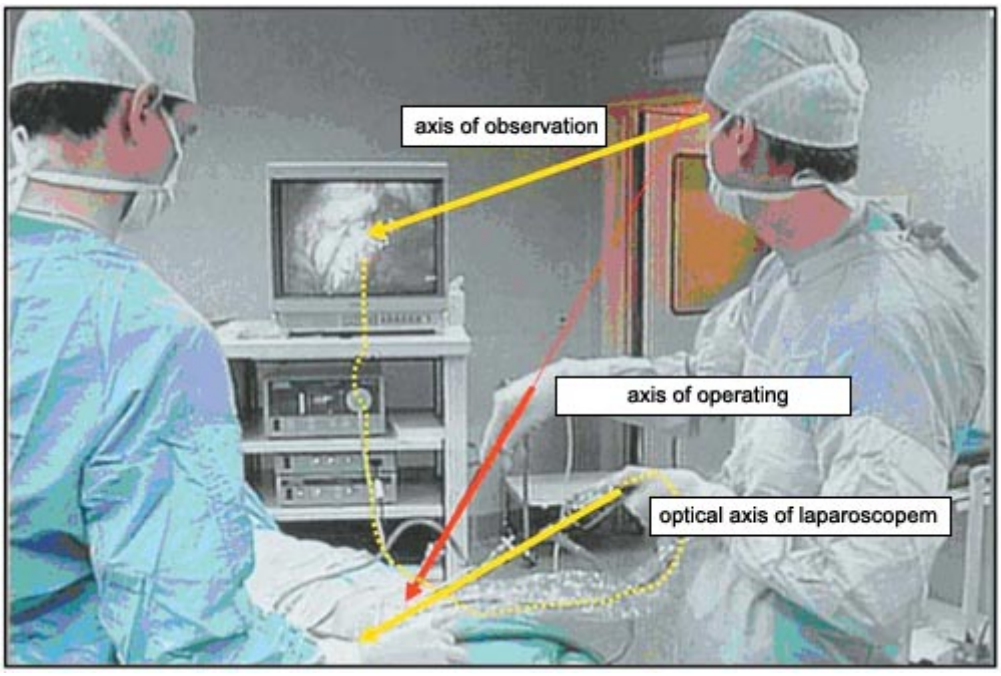
The systemic consequences in the laparoscopic operation are very small, because gas pressure on the peritoneum is much smaller than the pressure of dilator, surrounding material and surgical group hands in the open intervention.

Never the less, at some conditions long-term pneumoperitoneum can bring to some systemic consequences. This particulars should be taken into consideration in the patients of elderly and geriatric age, and in the patients with sever concomitant disorders. Video laparoscopic interventions should be done with precautions and the use of low pressure technique in the cavity and so on.

Wide surgical possibilities and minimal trauma of this method led to the revolution in surgery. From diagnostic procedure laparoscopy became a modern, universal and very sparing surgical technique, real "golden standard" of small access interventions.

Definite "tenderness" of surgical instruments made the technique itself less bloody. With its help a lot of surgical procedures and operations are carried out. Such as gastrectomy, liver and pancreas resection, large intestine interventions, cystprostatectomy, uterectomy, kidney's operations, adrenal gland surgery and abdominal aorta surgery.

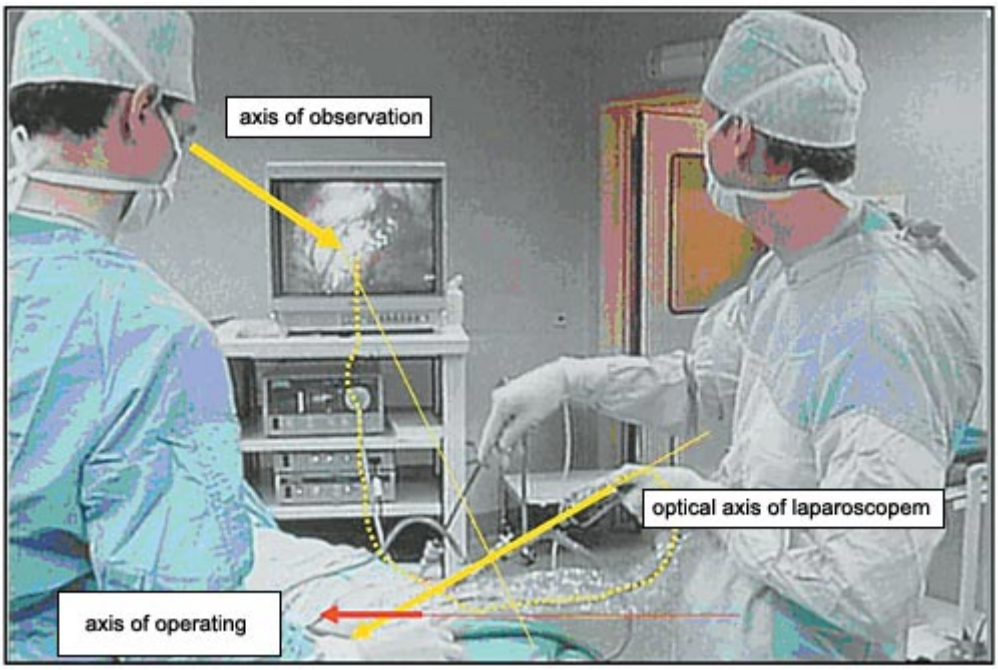
Clearly distinguished advantages of laparoscopic interventions (post operative pain and other functional disorders decrease, smaller treatment longevity, reduce in expenses for care and drugs, cosmetic outcomes improvement) predispose its wide usage and its preference in the clinical situations. Evaluating the principal opportunities of "hard" endow video surgery we must remember, that to operate in such a way is not easy (Picture 17)



Picture 17. Video laparoscopic operation. Relevance of the axis of observation and operating action for the surgeon.

The surgeon sees the object not where it's in reality, and he manipulates with it not where he sees it.

For the assistant the situation is even more difficult. (Picture 18)

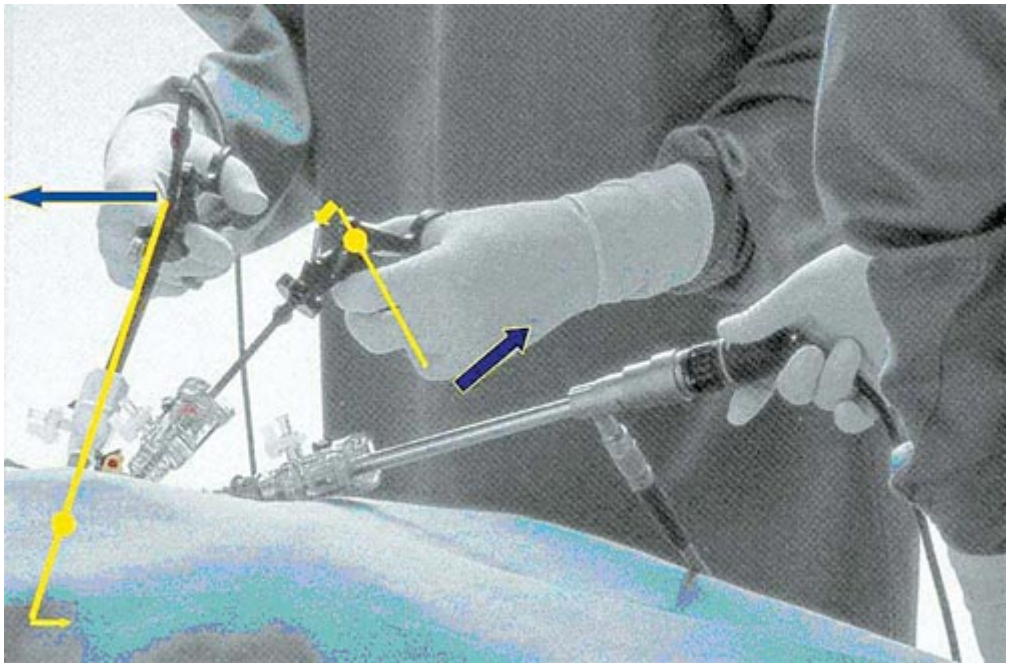


Picture 18 Video laparoscopic operation. Relevance between observation axis and operating action axis for the assistant.

The operating object on the monitor can be turned upside down, or reflexible for the assistant, and operating action axis shifting from optical observation axis on the monitor can be 180 degrees.

Perhaps in the future it's possible to expect the appearance of electroscopic devices allowing changes in the picture angle on the monitor.

The usage of hard instruments makes surgeon surer in his actions. More over the possibility to give back a part of tactile feelings about the degree of tissue density and the adequacy of physical efforts can be present. There are some limits. The axis of operating action while using the laparoscopic instruments is a bent line that makes the movement of instruments more difficult. (Picture 19)



Picture 19 Video laparoscopic intervention. Surgeon efforts transmission.

Instruments are fixed on the level of abdominal wall. While their manipulating in the abdominal cavity the initial manual effort is transmitted through several levers of different shoulders. At that point the dosage of efforts and the transmission of tactile feelings are difficult. To get the skills several things are necessary. They are a long term training of surgeons, the ability to create the whole picture of operating field with the help of fragmented information, and the skill to manipulate the long instruments from the small surgical access.

Surgical access and its closure in the laparoscopic operations are done easier and quicker than in the open operations. But the main operating method is more difficult and takes more time.

This fact has a very important meaning in the choice of surgical method. The more difficult is the endo-surgical target, the more difficulties and the longer operations we have. While conducting very difficult interventions small negative consequences of little in intensity but too long surgical aggression, anesthetics and artificial lung ventilation may reach the level of trauma usual for traditional surgical operations. It can be even larger sometimes. The risk of failure and complications is higher than normal. In such cases we can not see not only the advantages of laparoscopic method, but the necessity of its clinical use.

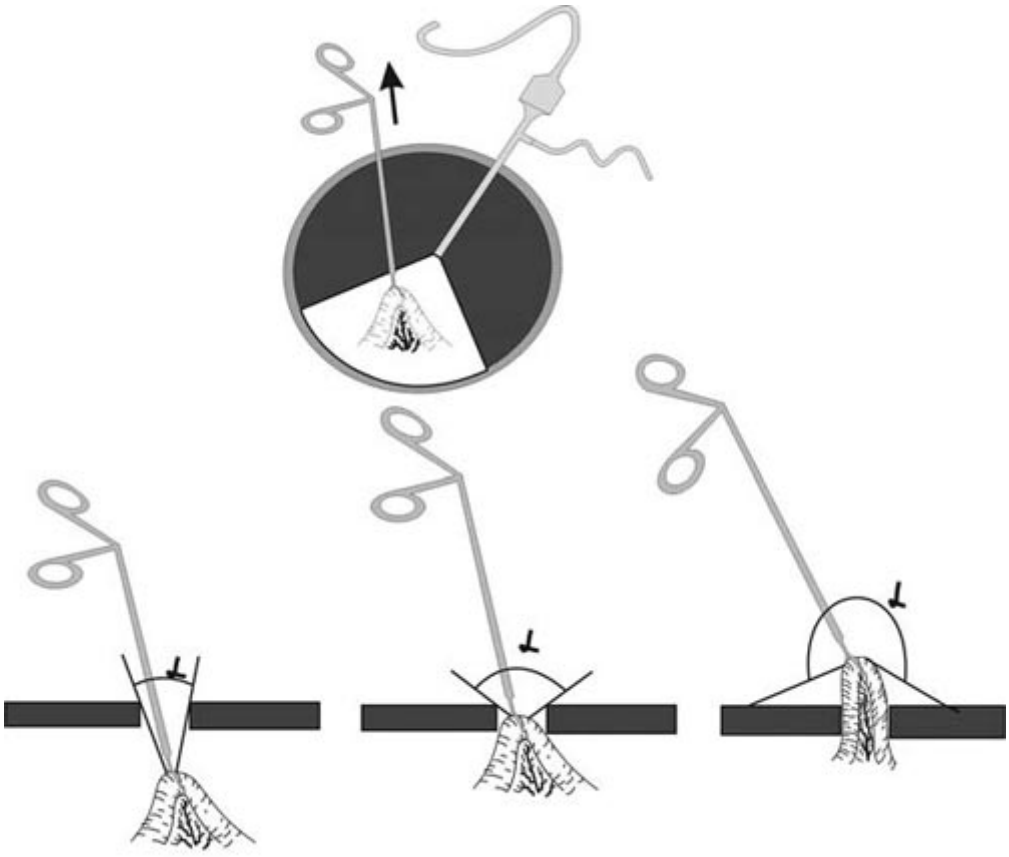
One of the reason for it is the over evaluation by the surgeon of his abilities and clinical indications for this particular method, and the desire to finish the operation with the initially chosen variant.

If a surgeon finds out the situation not suitable for laparoscopic intervention, if he understands the risk of intra operative damage (for example- thick inflammatory infiltrate) or in 30 minutes period he can't decide the anatomical problem, it's necessary to have a conversion. Laparoscopic operation should be stopped and the surgery should be carried on by another way. This way may be more traumatic, but it allows realizing the main treatment target treatment with the degree of reliability and safety for the patient.

From financial point of view laparoscopic interventions are usually more expensive than conventional ones. But their appliance is very often cheaper, because the post operative treatment and rehabilitation cost is much lower.

Laparoscopic assisted (added) surgeries are one of the widely used simple variant of surgeries. The basis of this direction was the papers of I.D. Prudkov (1968-1975), who offered the technique of sparing operations on the mobile organs of abdominal cavity.

This technique required laparoscopic revision of abdominal cavity, laparoscopic capture and taking the part of the organ outside through the puncture or small incision in the abdominal wall. (Picture 20)



Picture 20 Laparoscopic assisted surgery.
Angle of operating action.

The main step of intervention was performed outside the body with the appliance of conventional technique of open operations. The operation was finished by suture of organ wall to the front abdominal wall (organostomy) or by closure and emersion into the abdominal cavity (organotomy).

Organ extraction from the non-spacious conditions sharply changes the conditions of surgical intervention. As in the case of discrete access there is an angle of operating action characteristic for classical operations. Its meaning can be 10 degrees and more, that is much more than the angle in laparoscopic interventions from several punctures. More over not taking into consideration the size of it the access is open that gives optimal conditions for surgeon actions.

The size of abdominal wall wound stops being the limit factor. In reality all limits for using the successful applying of most classical procedures are not present. All without exception tactile feelings come back. The opportunity to conduct the most difficult step of intervention easily and quickly appears, the trauma of operation changing not considerably.

In the meanings of terms these interventions are not laparoscopic, because the laparoscopy doesn't solve all the problems. These are the operations with laparoscopy, with its help. After appearance of endovideosurgical equipment and instsruments this technique got its further development, now days it's known as laparoscopic assisted or added operations.

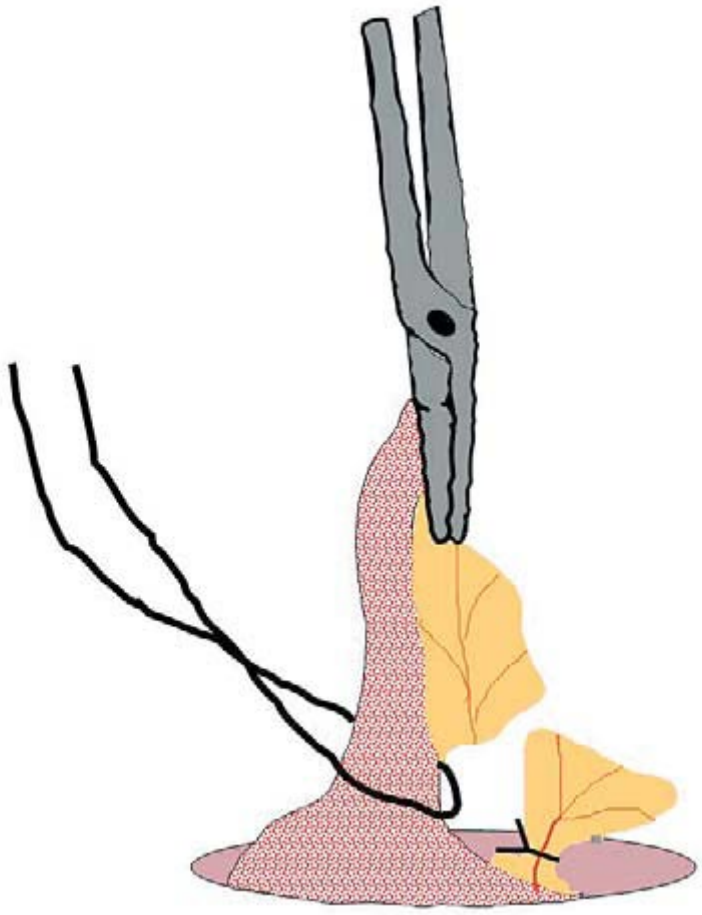
Such laparoscopic assisted operations are use in modern endow videosurgery for the shortening of time and simplifying the most complex and responsible operations, for example large intestine resection with repairmen of its potency.

Another more traumatic variant of laparoscopic assisted intervention is the usage of “hand of help”, which surgeon inserts deep in to the abdominal cavity through the special wide port and continues the intervention combining the opportunities of video laparoscopic surgery and direct manual operating.

Interventions through the small accesses

The desire to conduct the operation from the relatively small access should be considered historical first variant of small access surgery. At the small depth and relatively flexible organ, interventions requiring the classical technique of open surgery from small access still exist. As an example we can name the widely used method of removal of worm –like appendix through the local vertical access in the right iliac field (Mc Burney access or Volkovitch-Djakonov access).

The size of access is not enough for inserting the surgeon’s hands into the abdominal cavity. But in many cases there is no necessity for it, because the depth of access is not large and is smaller than the fingers length. Operating area volume is also small but it has the classical shape of cone widening in the direction to the operator. Surgeon hands are not in the wound and they do not close (interfere) with the operating zone. Operating action angle is many times larger than limits for conventional operation. (Picture 21)



Picture 21. Appendectomy from the local access.
After the extraction of worm-like appendix together with cupula of cecum from abdominal cavity into the small incision of abdominal wall, the limits of open manual technique of operation disappear.

Described above method of appendectomy have been successfully used since 1894. But the basis of its “life span” is the possibility to change the surgical situation after extraction of cecum cupula and worm-like appendix from the abdominal cavity.

As a result all limits for the classical surgery disappear. The whole surrounding field becomes available for the hands and instruments' work, the angle of operating action being much more than 180 degrees.

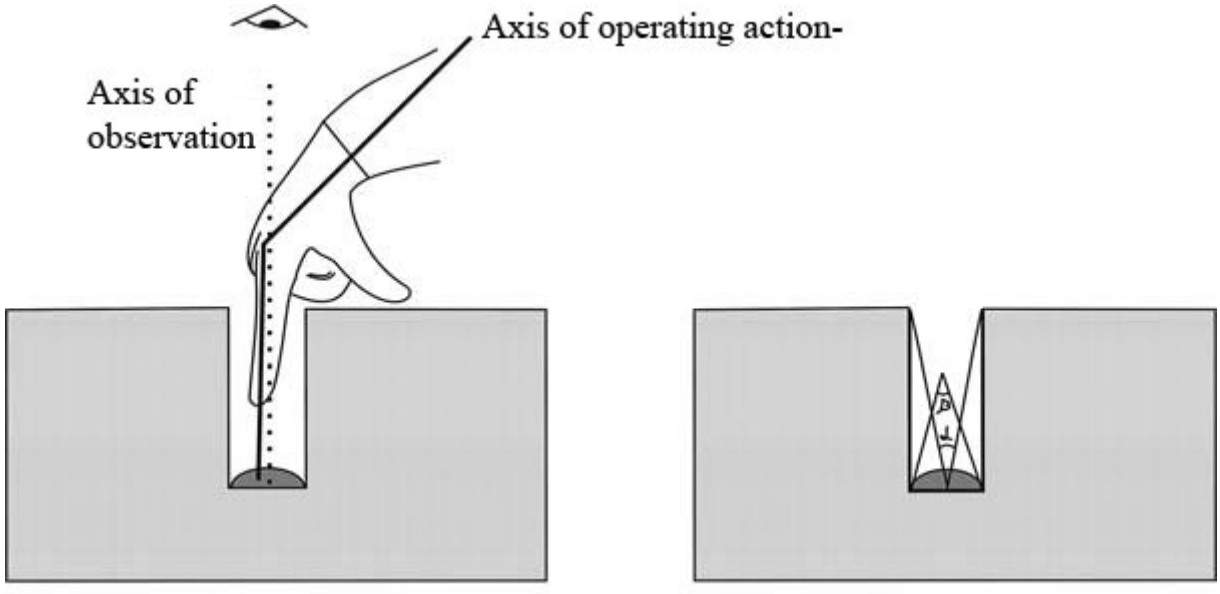
The wound size, damaged tissues and degree of their damage state relatively small.

The attempts to work out the technique for conducting operations on the deep organs through the small well-like access were taken in many countries at different time.

At the beginning of 20 century P. Clairmont described the technique of cholecyctectomy through the small access.

"During the operation the small access is quite uncomfortable, but in post-operative times it's much more preferable for the patient" (R.Stich, M. Makkas, 1928).

Such interventions are rarely successful. But with the depth increase the operating conditions become difficult. The angle of operating action becomes less, instruments and surgeon hands start interfere with observation area, straight tactile feelings disappear, and not enough length of wound gives limits for opening and movement of instruments. (Picture 22)



Picture 22 Deep well-like access and traditional technique of operation.

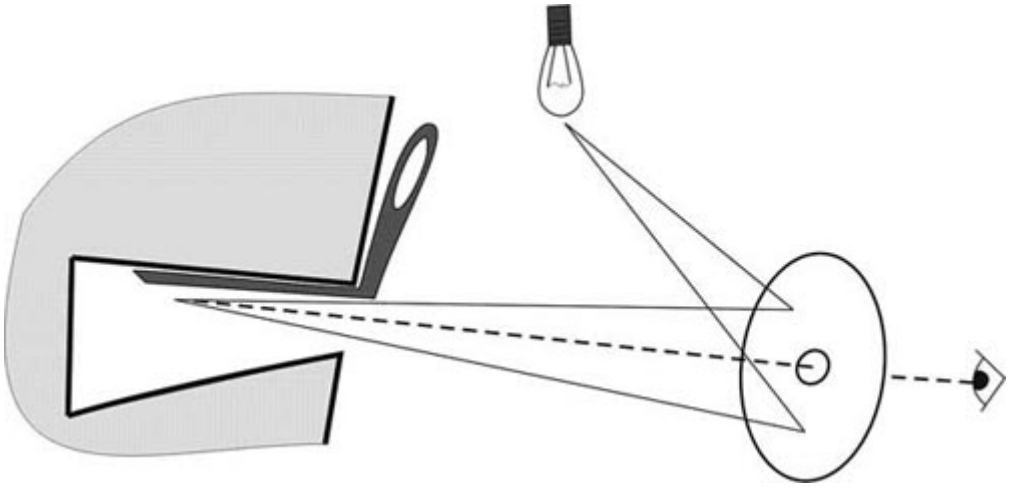
As a result even in skillful hands and with thorough patients choosing (early stages of disease, complications absence, and favorable anatomical conditions) the number of failures, conversions and complications are too high.

Conditions of deep well-like access harden the united actions of surgical team. Assistants don't see the zone of operating and their help is not effective.

For the majority of surgeons such a way of operations is still not acceptable.

Open endosurgical operations through the small accesses

The basis for this group of techniques was the first variant of laparoscopy. It was the straight visual observation of inner tissues and organs with the help of blade- type retractors (narrow long "mirrors") and the light coming from the forehead reflector. (Picture 23)



Picture 23. Ventroscopy by Ott.

This method was suggested by D.O. Ott in 1901 for the observation and conducting the interventions on the organs of small pelvis through the vaginal celiotomy.

Endoscopic revision and endosurgical intervention were two revolutionary elements which widened the surgical opportunities of small access. 70 years before the endosurgery Ott and at. al. successfully conducted the wide range of operations on the small pelvis organs including even uterus removal.

Modern blades like retractors have more effective system of enlightening the inner organs (glass fiber, light diodes). The same interventions are used in modern surgical practice including conventional ventroscopic operation by Ott. But their usage is limited to the relatively easy operations and procedures – revision of deep open wounds with the help of blade like retractors, inserting of drainage, washing of deep pockets, removal of free sequester.

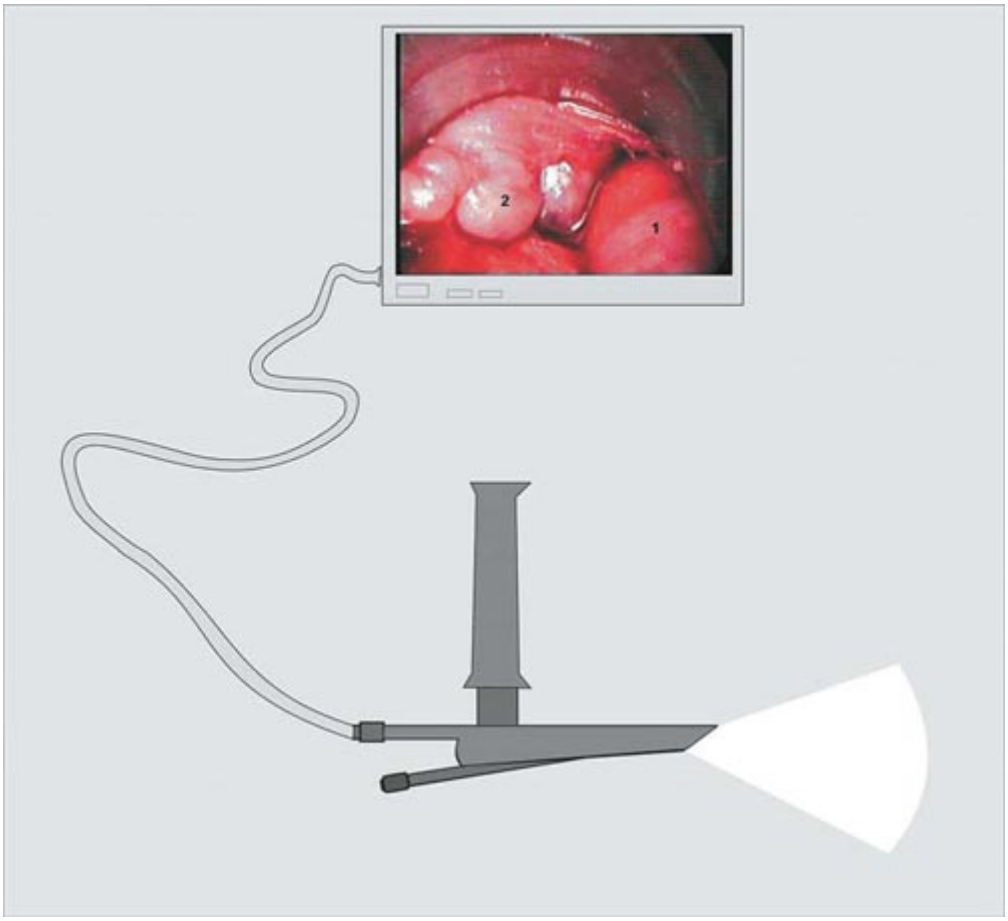
Their main advantage is the simplicity of operating, disadvantage is non stable operating field.

“Tubas” interventions are done due to tubas retractors. Their main target is to provide the stability for the operating field. The wound size is usually 3-4 cm; depth is 6-8 cm and more. Both angles of operating action are relatively small, that narrows the usage of surgical methods.

Operating field is stable. Its shape is a narrow cylinder or a narrowing cone. This variant allows using of endosurgical instruments and technique. But its usage is limited by the small zone of accessibility and too narrow operating field.

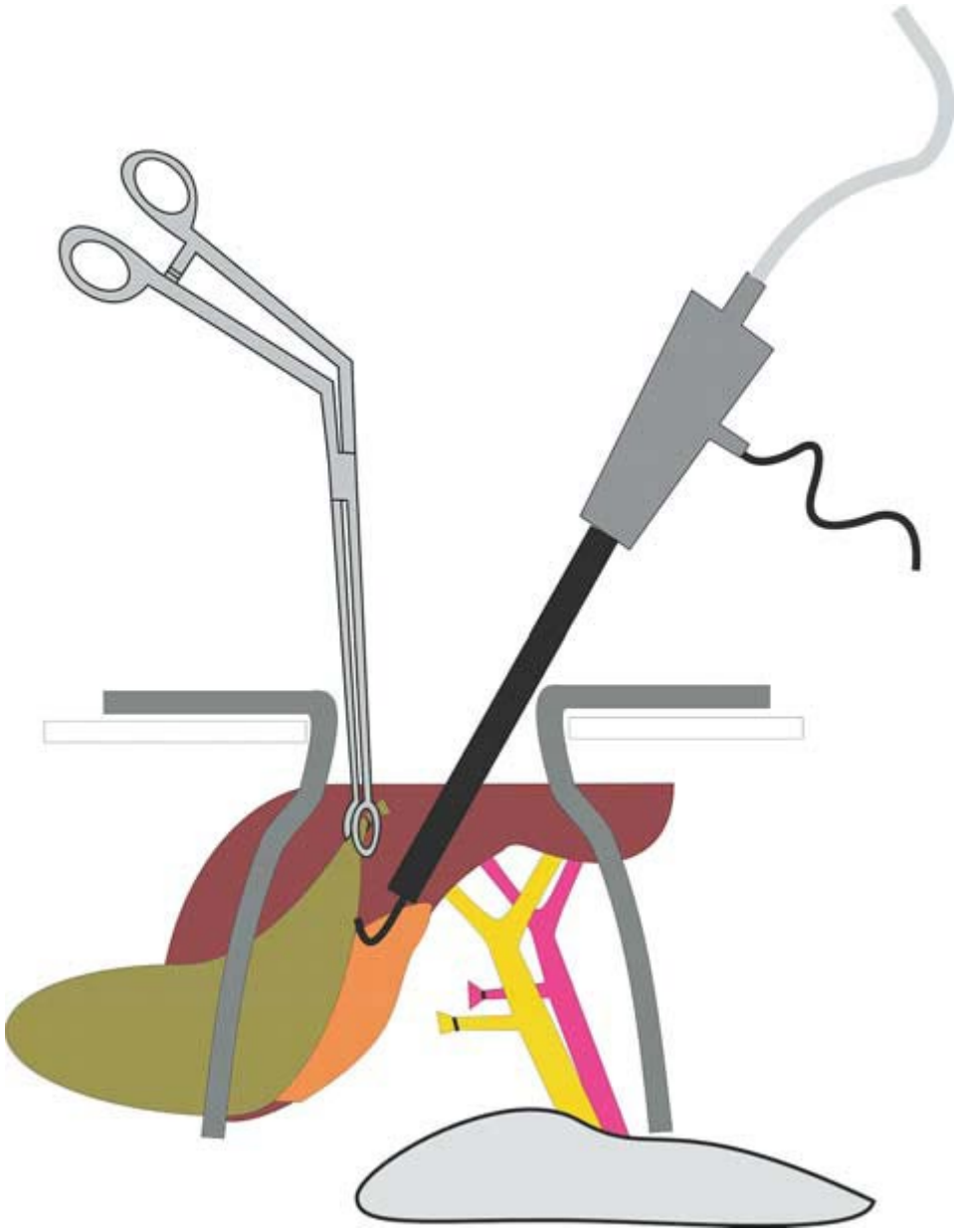
The zone of access at the horizontal cut coincides with tubas diameter and is hundred times smaller than at classical variant of laparoscopy. To enlarge this zone butt cut in retractor is done under the angle to the longitudinal axis.

In order to improve the quality of visual observation modern equipment for lightening the operating field and endo-video support is used. (Picture 24)



Picture 24. Retroperitoneoscope with endo visual support.
This method has limited opportunities and is used to conduct not difficult endosurgical procedures in the depth of tissues (manipulating mediastinoscopy and retroperitonioscopy, rectoscopic transanal interventions, subcutaneous and subfascial dissection of low extremity veins, small cellular spaces surgery).

Open endosusrgical interventions through the widening small access. (Open laparoscopic interventions, interventions through the mini access according to M.I. Prudkov) have been used since 1981 (Picture 25)



Picture 25. Cholecyctectomy through the widening mini- laparotomic access.

Principal difference of this type operation is the forming of stable surgical access of cone type which widens into depth of tissues in the direction of operating object.

Very often for their conducting special circle wound dilators are used (“Mini- Assistant”). Differently from laparoscopic and ventroscopic techniques, the shape of operating space is supported with the help of fixed mirrors. It allows creating, supporting and moving the stable operating space in the depth of tissues, taking the organ-target out in to the center of access zone.

At the 3-5 cm size of skin incision the volume of free operating space in gallbladder operations is quite large. The zone of accessibility is almost the same as in the traditional laparotomic cholecyctectomy, and the operating space volume is only 2-3 times smaller.

Practical meaning of these differences is even smaller. The space under the liver is limited, and a small incision makes it larger only in small degree. More over, in traditional cholecyctectomy the main part of under liver space is occupied by the surgeon hands and is not free.

The optimal access depth must be 5-15 cm. At the smaller depth of the access it’s two difficult to form the necessary volume of free space. Two deep access makes the manipulating more difficult.

While operating on the bile ducts the depth of mini-laparotomic access is twice smaller than video laparoscopic, and is 6-10 cm, giving quite comfortable conditions for the operating.

The zone of accessibility from one incision is limited by the borders of one anatomical field of abdominal cavity or the half of two semidetached fields.

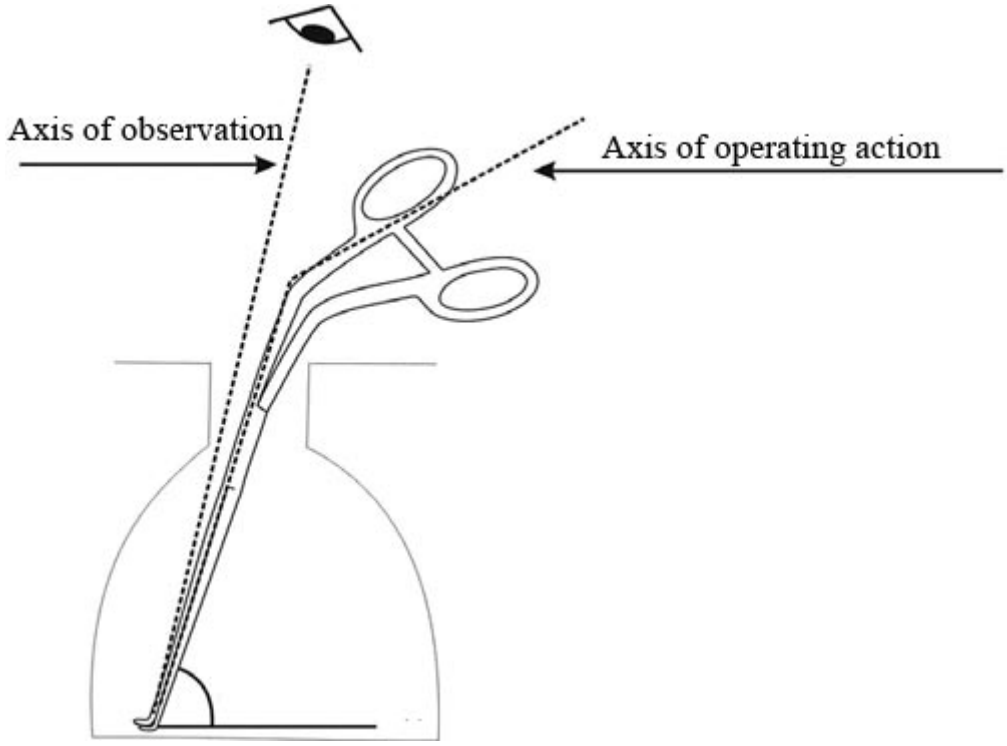
The way to control is the straight visual observation, “Peeping” across the wound edges without the optic devise (“open” laparoscopy), allowing to see the operating zone without shifting of volume, color, optic and apparatus aberrations.

The axis of observation is a straight line.

At the same time the surgeon has the opportunity to perceive the object of operation, and what is more important, he has tactile feelings of tissues density.

The conditions allow using of traditional devices improving the quality of observation (surgical forehead lens, operating microscope, endovideo support).

The axis of operating action is a bent line. In order not to interfere with it the instruments must have a particular curve, and their working tips must be extracted to the side. (Picture 26)

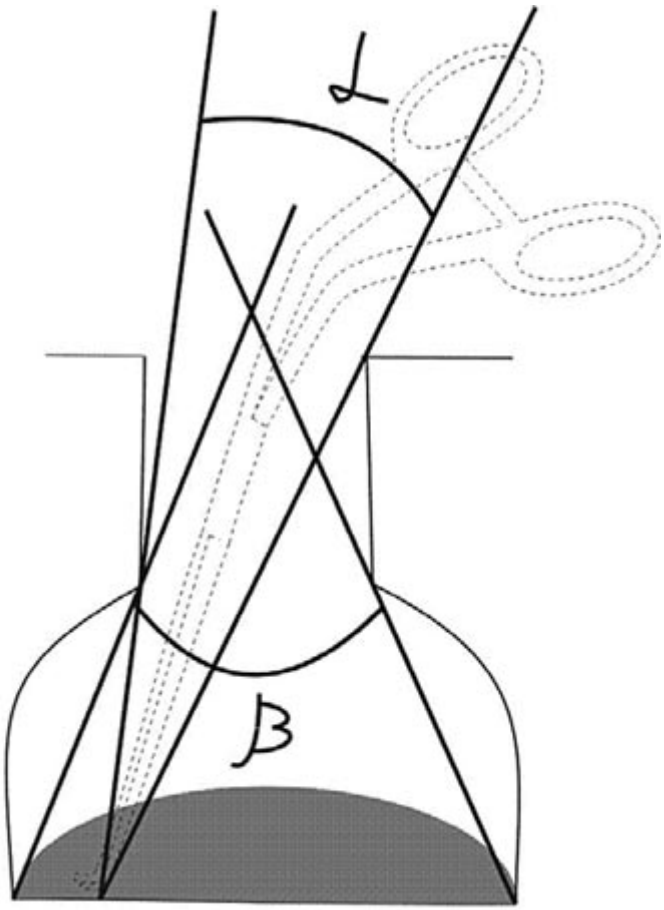


Picture26 Instruments for the operations through the widened mini- access.
OH –Axis of observation-AO.
OOD- Axis of operating action- AOA

Used instruments according to their construction are similar to traditional ones. Not a large access depth and not countable inner loss for friction in the instruments allow the surgeon to follow the usual skills and feelings.

Ergonomics of instruments is worked out according to the operating space parameters. The conditions of operating allow using of the majority of special devices for operating in the deep wounds for dissection, destruction and aspiration, laser and temperature influence, electro surgery, argon coagulation, coagulation with the effect of collagen structures melting and so on.

The widening access gives the opportunity for manipulations of two types with the appropriate angles of operating action. (Picture 27)



Picture 27. Widened mini-access. Angles of operating action.

The angle of operating action for the classical operations has the important value. In cholecyctomy it's usually 30-50 degrees.

For the endosurgical technique the angle is much larger. The sum of two angles is more than 90 degrees. It gives the freedom for the instruments actions, provides the simplicity and wide surgical opportunities.

The traumatic effect of these operations is not large and quite correlative. But there are some differences. The volume of locally damaged tissues is a bit more, that eventually brings the risk of wound complications. But in the absolute numbers local surgical invasion remains very small.

In order to operate through the small access (including the widened one) there is no need to have volumes of free space comparable with the abdominal cavity volume. So the excessive pressure on tissues and deformation and pulling of abdominal walls are not necessary. That's why the whole mass of locally damaged tissues and the degree of their damage are dozens time smaller than in conventional operations from the wide incisions.

Differently from videolaparoscopic operations, endosurgical interventions from widened mini access leave the organs not in the zone of operation intact.

They do not interfere with respiratory excursion of lungs and venous flow to the heart. It makes them preferable in old and geriatric patients with severe chronic disorders.

A little manifestation of local disorders and systemic consequences after operations decrease the necessity of anesthetics and following intensive therapy, decreases the in-patient treatment time and rehabilitation.

Economically this method is cheaper, simpler and easier to fulfill than laparotomic and video laparoscopic operations. But the opportunities for its appliance are limited in 1-2 anatomical fields. In general the use of endo-surgical abdominal interventions from the widening mini-access is suitable for local surgical operating in the cases where video laparoscopic interventions has no rationality, but it's quite possible to do without wide laparotomy.

Traditionally this technique is used in emergency service and in the general in-patients departments for the geriatric patients, for the operating correction of complex local pathology, and to conduct the most difficult steps of combined mini-invasive surgery.

Small access robotic surgery requires another principal of wide surgical opportunities of endovideosurgerywiththe most updated technology.

The term "robot" was introduced by Czech writer Karel Chapek in 1921. Since the very appearance of endovideosurgery the working out of devices on the robot base has started. The turning point in the development happened in 2000 when the first integrated robotic system daVinci® appeared in the USA. This system got a very wide clinical use as a universal high-tech robot leaving the surgeon without the difficulties of indirect observation and operating.

Mini-invasive interventions with robotic systems are done with special instruments through the puncture ports.

The characteristic feature is the presence of drives (gears) system in every instrument. The drives provide the movement of working parts and additional "joint" on the working tip (circling, bending). Every single instrument gets the extra freedom of actions with significant endosurgical angle of operating action. (Picture 28)

Picture 28 Robotic systems in small access surgery. Abilities of instruments.
Every single instrument gets the extra freedom of movement with significant angle of endo-surgical operating action. The opportunity to duplicate the movements of surgeon hands and fingers appear.

As a result the working parts of instruments get the abilities of human hands. Surgeons get the possibility to operate not with the help of two but with three “hands”, and even more.

So, activating the manipulator the surgeon can take and shift the interfering organ. The deactivated manipulator stops moving and fixes the organ as a mechanical “assistant”. The surgeon can activate the next one and go on with operation.

Outside the body every instrument is attached to its mechanical “hand” by the special connector. The “Hand” has its own system of hinges and drives governing them.
Manipulators movement in the space and instruments movement inside the organs are done so that trocars position in the wound is the same.

Surgeon hands are in ergonomic position with the support on the handles. His fingers and hands fix particular organs of governing the system. The system is organized so that instruments copy the fingers and hands movement.

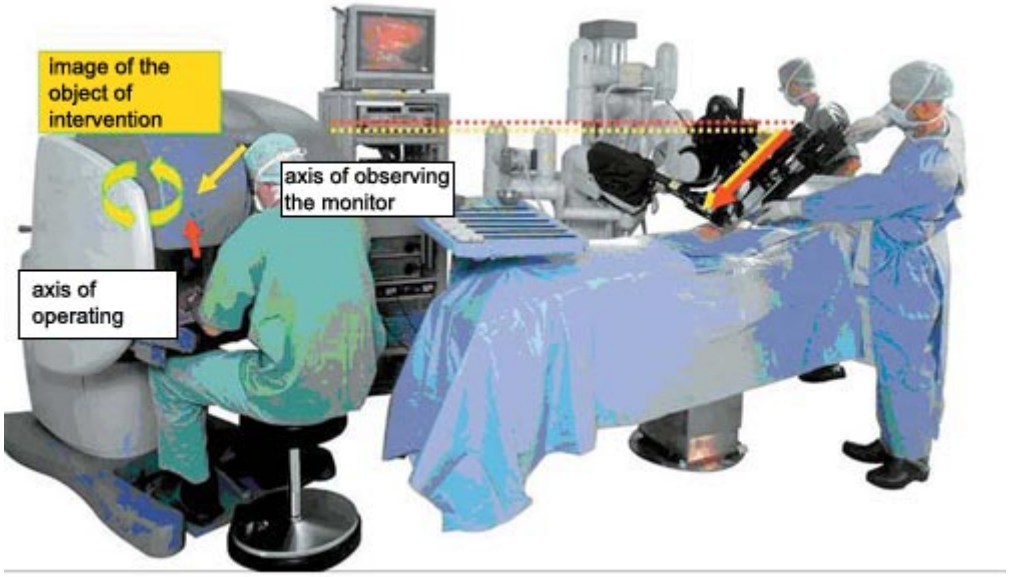
Taking in to consideration the load and the necessity of guaranty, instruments have microchips limiting the length of working time. The working place of a surgeon consists of computer system, stereo monitor, a chair. The observation is conducted through the stereo laparoscope and a special video camera attached to the stereo monitor. Observing the screen the surgeon can see volumetric and high quality picture of the manipulating zone.

The place of laparoscope in the abdominal cavity changes automatically according to the changes of surgeon head. This system can change the size of the movements and can suppress the tremor. Additional information can be used. E.g., a picture of structure of surrounding organs and tissues done by CT and MRT.

The change of instruments is done by assistants. Observing the operation on the other extra monitors they can help the surgeon. Operator can be in the surgery, next door or on the large distance from the patient.

A surgeon’s sight direction and the pose of his hands always co-inside with the object picture and instruments on the monitor. It gives the surgeon the whole perception back.

The device gives the opportunity to change the picture angle on the screen n of the monitor and “rebuild“ it in accordance with true axis of laparoscope and the axis of instruments. The surgeon has a sensation that he is inside the body, and the instruments are the continuation of his hands. (Picture 29)



Picture 29. Robotic systems in mini-invasive surgery. Axis of observation and operating action.

Surgical opportunities of robotic surgery are great. The time of conducting the most difficult operations is much less, which brings the decrease in postoperative trauma.

Principal opportunities of robotic surgery come to the level which could be reached earlier only by conventional interventions from traditionally wide access. The training and leaning of new operations and procedures are much easier.

The negative aspect is a high cost of robotic surgery, and the absence of back tactile feelings which can make work of operator so easy. Perhaps in the nearest future we should expect the appearance of systems with the back tactile connections. For example, it may be a scale for registering the squeezing power instrument working parts. It may be another analogue system making easier the other types of small access interventions.

Problem of choosing the technique and combined operations

Appearance of small access interventions and their variations bring the multi variability of surgical treatment.

Nowadays every surgical operation may be conducted by several ways. The severity of disorders, outcomes, risk of complications and treatment expenses can be very different.

The number of surgical variants is constantly growing and in accordance with scientific progress it will grow even rapidly. It's not easy to make the right choice. One way to solve this problem is standardization and establishing the boarders for different small access interventions. It must be done on the basis of comparing the opportunities, effectiveness, and economical effect of different methods. They must be evaluated in the natural conditions of use (out- patient surgical help, general net of non specific surgical in- patient departments, surgical centers, and private clinics).

Another very important decision can be found in the combination of mini- invasive interventions and their elements in the process of one intervention fulfilling. Every single stage of surgery (access for the surgical revision, surgical revision itself, extra access for the main stage of operation, main operating technique, finishing the operation) must be carried out with the help of suitable technique. In future it'll make small access surgery more effective, safer and economically proved.