

## NOTES in patients treated in intensive care units – the new challenge

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### Abstract

*The paper presents the possibilities offered by NOTES technique in patients treated in intensive care units. They constitute a group of patients in whom establishing the correct diagnosis encounters many difficulties and in whom it is particularly desirable to minimize injury after surgical intervention. This is the reason why NOTES could be a convenient procedure to explore the peritoneal cavity. Moreover, in this research we would like to point out the necessity of overcoming barriers in the way of minimally invasive surgery.*

**Key words:** endoscopy, intensive care unit, NOTES.

The paper presents the possibilities offered by natural orifice transluminal endoscopic surgery (NOTES) technique in patients treated in intensive care units. They constitute a group of patients in whom establishing the correct diagnosis encounters many difficulties, and in whom it is particularly desirable to minimize injury after surgical intervention. This is the reason why NOTES could be a convenient procedure to explore the peritoneal cavity. Moreover, in this research we would like to point out the necessity of overcoming barriers in the way of minimal invasive surgery.

The dynamicity of surgery development, which one can observe in the last few years, greatly depends on the progress of technical science. A prime example is the revolution in surgery related to the introduction of laparoscopy. Inaugurated 20 years ago, due to constant improvements of tools and techniques, laparoscopy is still extending its capabilities. Recently an entirely new branch of surgery has been developed: NOTES [1]. It is a technique based on endoscopy of the gastro-

intestinal tract, which also adopts the latest achievements of laparoscopy. In this field, in the medical community there are many controversies accompanied by vivid discussions regarding selection of the most appropriate operational methods for the treatment of specific disease entities.

However, if we looked at this problem from a different perspective, we would realize that in some conditions NOTES could be particularly justified. This mainly concerns a group of patients who are treated in intensive care units (ICU). These are patients who are usually unconscious, who need mechanical ventilation, parenteral alimentation, dialysis, and permanent monitoring of life functions, as well as treatment of serious infections. Minimizing the operation trauma among them would be a great achievement.

According to statistical data, a quarter of patient deaths in ICU have been caused by pathologies which were not recognized until the post mortem examination [2]. Some of them died as a result of generalized infection caused by either unre-

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cognized outbreak of infection located in the peritoneal cavity or ischaemic bowels [3]. If half of those infections were recognized at an early stage, this could have significantly improved the outcome of treatment.

Upon well founded suspicion of infection located in the abdominal cavity, in addition to typical clinical and laboratory examinations, we can perform USG and CT of the abdomen, exploratory laparotomy or laparoscopy. In assessing the above diagnostic methods, it should be noted that only some of them may be implemented at the patients' bedside. Computed tomography, in seriously ill patients, is very difficult to conduct, especially among those who are haemodynamically unstable with concomitant pressure decrease and cardiac dysrhythmias. The situation becomes even more complicated in the case of patients with impaired breathing, especially when connected to the respirator [4]. These factors affect the transport of patients to the CT laboratory.

In some cases there are indications to perform exploratory laparotomy. The statistical data prove that early diagnosis and treatment of intra-abdominal infections may reduce mortality by 25%. On the other hand, perioperative trauma is associated with adverse consequences for the patient. It is estimated that among patients with negative exploratory laparotomy morbidity is as high as 90%.

Regarding laparoscopy, it is considered to be a safe method of treating patients confined to ICU, but it is rarely recommended due to the inconvenience associated with carrying it out at the patient's bedside.

Whereas bedside gastroscopy is a routine diagnostic procedure, laparoscopy is performed to establish percutaneous endoscopic gastrostomy (PEG). In addition it has been observed that NOTES can provide a convenient and minimally invasive access point for peritoneal diagnostics, therefore decreasing the number of unrecognized severe intraperitoneal pathologies.

Recently there have been several publications presenting the use of NOTES in an animal model to explore the peritoneal cavity. The authors of those works discussed the successive steps of establishing access to the peritoneal cavity in animals [3].

Firstly they performed a gastroscopy. Secondly they placed a director in the stomach, which was introduced through the abdominal and gastric walls

– the same as doing it during the “pull through method” in PEG implantation. In consecutive steps they widened the incision in the gastric wall. The obtained aperture allowed the free passage of the gastroscope from the stomach lumen to the peritoneal cavity. In all animals investigated, they managed to show each quadrant of the peritoneal cavity. The inverted gastroscope position was used to visualize the subphrenic area. In order to assess the intestines and other organs more efficiently, standard endoscopic forceps were used. Moreover, a complete inspection of the peritoneal cavity could be obtained by introducing two additional mini-trocars by the abdominal wall.

After finishing the peritoneal cavity exploration, in the location of the gastric incision the percutaneous endoscopic gastrostomy was planted. The authors of those articles assumed that some of the patients treated in ICU would benefit from PEG, while implantation of a gastrostomy tube results in effective adhesion of the stomach wall to the abdominal integument.

When inspecting the peritoneal cavity, an attempt to evaluate other technical possibilities has been made. It has been pointed out that when using a one-channel video gastroscope the following procedures could have been made:

- 1) endoscopic biopsy of the spleen and liver,
- 2) electrocoagulation in the biopsy location,
- 3) intraperitoneal adhesion release,
- 4) fluid reservoir drainage.

As a result of the experiments it has been established that benefits arising from the use of by-the-bed NOTES in order to explore the peritoneal cavity are the following:

- 1) avoiding difficult and onerous transportation of the laparoscopic equipment together with the OR personnel to the ICU,
- 2) avoiding transportation of severely ill patients to the operating theatre or to the X-ray laboratory,
- 3) fast and easy peritoneal cavity inspection is possible,
- 4) NOTES technique allows for a quick second look,
- 5) significant reduction of the costs associated with use of the operating room to perform an exploratory laparoscopy or laparotomy.

Restrictions and drawbacks arising from NOTES were also determined. It has been found that:

- 1) it is a superficial method of visualization and it is limited to the intraperitoneal space,

- 2) it is an invasive method which can give complications,
- 3) the tools presented are unable to assess the intestines comprehensively,
- 4) it can be difficult in patients with intraperitoneal accretions after previous operations.

Complementary to the research presented might be a report from the clinical centres in which exploration of the peritoneal cavity was done using the NOTES technique. It was performed in patients with pancreatic tumours in order to refine the diagnosis, which is essential to choose an appropriate course of treatment [5]. In those patients after performing gastroscopy, the endoscope was passed through the stomach wall to the peritoneal cavity – as previously planned, the omentum, liver and parietal peritoneum were investigated in the search for metastasis. If indicated, a biopsy of the suspicious lesion was collected. Although the work cited does not apply to patients treated in the ICU, it should be quoted in view of observations made therein.

As a result of assessments made by the authors, it has been established that:

- 1) at the bedside peritoneoscopy is not only possible to be performed but is also of the same use as exploratory laparoscopy,
- 2) NOTES technique as well as laparoscopy allows a biopsy to be performed,
- 3) the authors of the research used a one-channel video gastroscope; in their opinion it is more useful for performing peritoneoscopy than the two-channel therapeutic gastroscope, which has been proven to be too large and uncomfortable while carrying it through the gastrostomy and during examination.

Regardless of the typical diagnostic application of NOTES, it should be noted that there are also reports of other opportunities to use this technology in the ICU.

There is growing interest in the possibility of using NOTES to implant a phrenic nerve stimulator [6]. With this device, some patients may be temporarily detached from the respirator. Candidates for phrenic nerve stimulator implantation would be those suffering from spinal cord damage at the C1-C2 level and requiring permanent mechanical ventilation.

The phrenic nerve stimulation device has been available for many years, but unfortunately the traditional method of its implantation requires thoracotomy. Therefore the possibility to replace this

technique with a less invasive one, performed additionally by the patient's bed, has met with considerable interest.

Another example of the practical application of NOTES in terms of the ICU is a case report of a patient with severe central nervous system damage caused by stroke [7]. The patient had been previously set up with a tracheostomy and PEG for enteral nutrition. On the third day after performing PEG, the gastrostomy tube was protruded from the stomach to the peritoneal cavity. Firstly an open operation on the abdomen was considered, but due to the patient's serious condition this kind of treatment was excluded. Instead it was decided to perform gastroscopy and subsequently using the existing incision in the stomach wall the endoscope was introduced to the peritoneal cavity. After inspection of the abdominal cavity and suction of the gastric contents, using endoscopic tools, nutritional gastrostomy was recreated.

It should be noted that the authors of these scientific papers draw attention to certain limitations found while performing NOTES procedures. They usually arise from the lack of appropriate tools. The equipment currently available still does not provide for the operator appropriate freedom of movement or adequate visualization. This barrier can be overcome through proper technical solutions [3, 8, 9]. This is a challenge for engineers, technicians and designers together.

A very good way to overcome this problem was found in Norway. In Trondheim the "Medico-Technical Centre" was established, consisting of one of the most modern clinical centres in Europe – St. Olavs Hospital. Nearby, there are scientific and technical faculties of the Norwegian University, as well as the headquarters of the Scandinavian Institute with its agencies for research and development of new methods and medical technologies. One of the main purposes of St. Olavs Hospital is to develop new solutions in terms of minimally invasive techniques. The doctors employed in the clinic are in direct contact with the teams of technicians and scientists working in the two neighbouring sites, which facilitates the continuous exchange of ideas and experiences. Through the combined effort of people from different specialties in science and technology the tools of the future are constructed.

Among other solutions developed in Trondheim, a modern system for navigation and visualization was created.

As the available information suggests, the essence of this system lies in the fact that the camera of the laparoscope or videoscope is not the only source of the image obtained by the operating surgeon; it is the sum of data from a number of different devices such as ultrasound, CT, laparoscope or videoscope. Information acquired from these sources is then processed by computer and a program designed specifically for this purpose. Additionally the image is modified by the data gathered during the preoperative diagnostic imaging. Not until this enhanced form of image is obtained does the surgeon gain a full view of the operating area and its neighbourhood. With the system of navigation all the surgical tools are precisely located in the abdominal cavity, which concomitantly allows for a substantial increase in security.

The development of operations through the natural orifices also tends to reflect on the future image of the operating room. The question arises whether the future operating room will resemble a very well equipped endoscopic laboratory, or it will remain intact but enriched with endoscopic equipment [10-12]. Time will tell which scenario will be implemented.

In order to perform bedside operations, the equipment of the future operating theatre should be distinguished by a significant level of mobility, allowing transfer outside the OR.

It should be noted that the surgeon's operating environment has changed remarkably in recent years. There have been numerous modern devices, related to minimally invasive surgery, introduced to the operating room. Nevertheless, there is still a variety of complex devices and wires connecting them. Working with this equipment is becoming increasingly difficult. To ensure transparency of functioning there have been developed systems of control and management, which work in the framework of integrated operating room systems.

Such systems, controlling the expanded electronic equipment, are also needed at the time of bedside treatment using the NOTES technique performed in the ICU, where the quantity of complex devices is extremely high.

## Conclusions

1. An important reason why operations in the NOTES technique should be practised in intensive care units is the possibility to avoid so-called non-

therapeutic laparotomies. This especially concerns critically ill patients in whom there are no pathologies that require surgical intervention and those patients with lesions giving the chance for cure, such as extensive bowel ischaemia.

2. NOTES technique could play a significant role in peritoneal cavity examination among patients treated in the ICU; moreover, some of the procedures used nowadays could be replaced by minimally invasive techniques.
3. The development of all minimally invasive procedures, such as NOTES, should be a challenge for all science and technical teams in order to determine new technologies that influence patient safety and enhance the technical capacity.

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