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Determinants of Knowledge-Based Improving Workflow and Communication within Surgical Team

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***Abstract*—**Surgical team consists of variety types of medical specialists possessing different kind of knowledge, motivations, personalities or abilities. This together with poor knowledge transfer, lack of information and communication technologies (ICT) implementations in hospitals can cause protraction of patient care processes and even jeopardize patient safety.

There is presented in the article the outcomes of studies on communication and workflow in surgical team in the background of different collaboration levels in healthcare system.

As a result the five determinants of improving workflow and communication within surgical team were indicated as well as knowledge-based tools and supporting information technology were proposed.

***Keywords*—**Knowledge transfer, absorption abilities, knowledge representation, information and communication technologies, cooperation.

I. Motivation

SURGICAL teams can be deemed for one of the most responsible, hardworking and simultaneously respected staff group in healthcare. The crucial reason of that is first of all the unique character of tasks they perform, which are rescuing human lives and people's health. In order to meet the requirements of effective and efficient work in wards a surgical team should act as homogenous unit, the attribute of which is teamwork. Particularly teamwork is characterized by an interrelated set of team member thoughts, behaviors, and feelings [1] and is the image of quality healthcare, yet often overlooked, however [2]. One of the features shaping the mentioned quality regarding teamwork is an impact on error reduction [3]–[5]. According to many researches, the communication aspects play here one of the key role [6]–[11]. For example according to [9], one third of communication failures have caused jeopardize patient safety due to interruption of surgical procedure as well as the cognitive and tension load during surgery and according to the study conducted by [11], the rate errors made in surgery caused by communication issue is 43%.

Expanding communication aspects as a research objective can be considered not only from surgical team point of view (see [12]–[15]). The studies have shown that the cooperative problems owing to poor communication and information transfer are the common issue in different kind of health care activities including hospitality and primary care.

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Because the team communication breakdowns are associated with degraded team performance [16] it is highly justified to look for and develop such methods and tools which could solve the defined problem effectively. There is different kind of ways to do it described in the literature: briefings and debriefing sessions, simulation plays, interactive seminars, workshops [17]–[27]. Such methods create mainly nontechnical skills and are based on human recourses management solutions. Despite their utility, the area of their application is narrowed to improving communication from operating room point of view. This article presents quite different approach to the problem: the surgical teamwork is reflected on the system approach, basically on hospital processes approach, where communication and knowledge transfer skills of surgical team are create as a part of wider knowledge management system supported by up-to-date information and communication technologies.

II. The Study Aim, Methodology and Material

Taking into account the descripted problematic area and the range of the study, the aim of this article is to identify and describe the determinants which should be used for creating a knowledge-based procedure of effective and efficient surgical work. Fig. 1 presents the research path to meet the study objective.

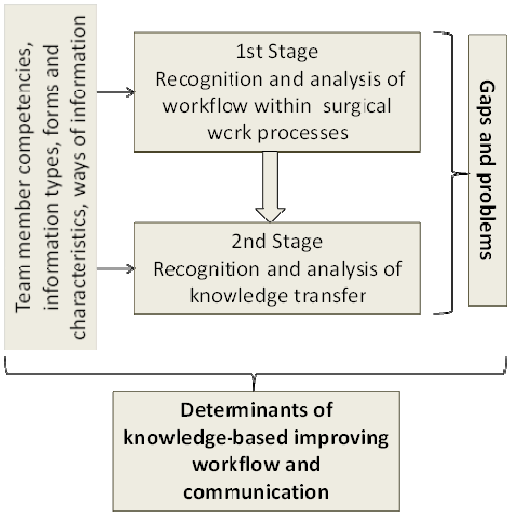

Fig. 1 The research path in the study

The important point of the research was conducting it on the background of specification of different wards and staff

competencies.

The main method used in the data collection and research material acquires to achieve the study aim was:

- direct observation of work processes, including the surgical procedures: arthroplasty, laparoscopy. The total number of observed surgical procedures is *n=8*, where *n=1* was hip arthroplasty; *n=1* was knee arthroplasty; *n=6* laparoscopic procedures. The research were conducted in *n=4* hospitals.

The auxiliary methods were:

- analysis of the literature in the field of communication, knowledge management methodologies and supporting ICT systems,
- free interview, including representatives of the following positions: surgeons, ward nurse, nurse, scrub nurse, medical sterilization techniques,
- questionnaire for knowledge transfer in the hospital, the total number of completed questionnaire is *n=42*, the number of hospitals is *n=2*,
- analysis of internal documentation, including medical records, operational techniques handbooks, manuals, catalogs.

The means of documenting and processing information obtained from studies were photographic and video materials, recordings of the results of verbal intelligence, process mapping, competence matrix.

III. The Result of Research and Discussion

A. Recognition and Analysis of Workflow within Surgical Work Processes - Surgical Team as a Part of Healthcare System

There was developed a layer model presenting the place and the role of a surgical team on the background of healthcare system (Fig. 2). There was highlighted the relations between particular member of the team and healthcare system components representing the workflow and the transfer of information.

A following abbreviations and simplification into the model is introduced:

- AW - anesthesiology ward,
- ST-OR- surgical team in operating room,
- SW - surgery ward,
- Te - technical unit,
- St - sterilization processes,
- Ad - administrative unit,
- S - surgeon as a head, assistant, operator,
- N - nurse as a ward nurse, nurse, anesthetic nurse,
- SN - scrub nurse as a main scrub nurse and assistant scrub nurse,
- A - anesthesiologist,
- The arrows -relations in areas of knowledge, human or material resources.

The staff indicated as S, N, SN, A create the team during surgeries.

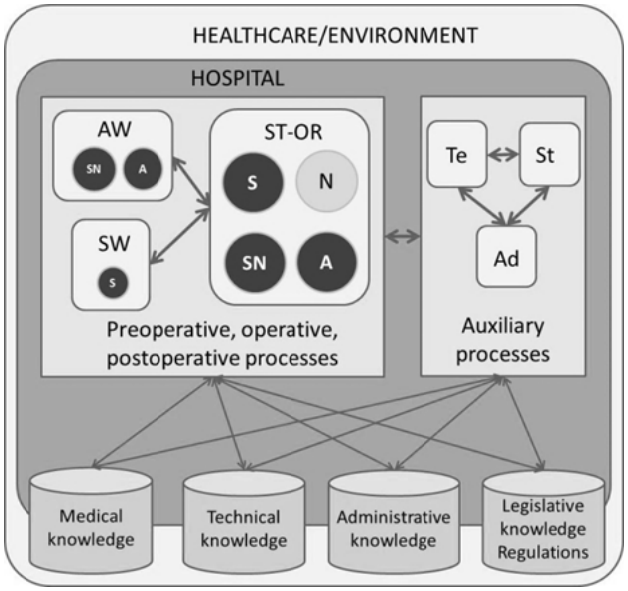

Fig. 2 The place of surgical team in healthcare system

The surgical processes demonstrate a high degree of their variety which is reflected in involving in the process different wards and units both medical and nonmedical and different medical and nonmedical staff.

Generally, processes at surgical units can be divided into:

- main processes (basic), directly felt by the patient, which are responsible for providing patient care services. These are the following processes: preoperative care, operative-surgery, post-operative care, discharging the patient from the hospital,
- auxiliary processes (invisible to the patient) supporting primary processes, conditioning the implementation of the core processes. These processes include: work conditions, the operation management of hospital technical infrastructure, including medical equipment and surgical instruments, management processes, responsible for the efficient functioning of the organization, including the management of human resources management, medical records management, etc.

In order to perform the surgery in effectively and efficiently way:

- patient must be diagnosed well, individually prepared before and treated after surgery, taking into account the knowledge about allergies, whole history of their disease, anthropometrical features, kind of surgery etc.,
- equipment and surgical tools must be checked from sterility, correct functionalities, availability, supply etc. point of view,
- rooms are prepared from infrastructure point of view,
- surgical tools must be disposed, assembled,
- whole medical documentation must be prepared including patient agreements,
- procedures must be performed under specific regulation and low,

– staff have to possess sufficient knowledge for carrying out their duties in best possible way, etc.

Despite the fact that the listed requirements are only a part of quality care assurance system in range of surgical treatment, it is observed a high degree of knowledge diversity and interactions between variety staff from different units. The problem is that particular member of surgical teamwork doesn't cooperate in frame of the same team neither during surgeries in operating rooms nor working in wards.

Additionally, taking into account the fact that surgical team consists of variety types of medical specialists who possess different kind of knowledge, motivations, personalities or abilities and that they can have different patterns of behaviors as well as different educational paths, the work on creating a formal method for improving workflow and communication within surgical team is quite problematic. The solution could be to establish the same fundamental rules in communication and accessing to information in whole organization using dedicated ICT tools.

A competence matrix was developed (see Table I) so as to order the observed phenomena in hospitals in range of knowledge needed to perform given process. There was used following designations:

– "x" to indicate that a type of knowledge is required,
– "e" to indicate that knowledge was a subject in standard educational paths,
– "-" to indicate that knowledge was not a subject in standard educational paths,
– abbreviations from Fig. 2 (Sym in first column in the Table I).

TABLE I
MATRIX OF COMPETENCE IN SURGICAL WORKFLOW

Sym	Medical knowledge	Technical knowledge	Administrative knowledge	Legislative knowledge and regulations
S	x/e	x/-	x/-	x/e
SN	x/e	x/-		x/e
A	x/e	x/-		x/e
N	x/e	x/-	x/-	x/e
Te		x/e		x/e
St		x/e		x/e
Ad			x/e	x/e

The multiplicity of tasks within hospital processes and surgical team requires multidisciplinary knowledge recourses. The study showed that there are several problem areas related to the knowledge management in surgical team:

– There are technical knowledge gaps among surgical team member. In particular technical knowledge is related to proper using and maintaining surgical tools and devices. The way of possessing such knowledge is usually: instructions, surgical techniques manuals, observations, less often trainings. As a result the staff participating in surgery use different degree of knowledge – this concerns even a tool names. The problem is particularly important by frequently staff rotation. The research conducting in one of the hospitals showed that there wasn't any time the same composition of the surgical team during one type of surgery.
– There are different degrees of knowledge absorption abilities among surgical team members. To a small extent, staff use the manual or manuals of surgical techniques, although they are a necessary basis for the proper use and maintenance of equipment and surgical expertise. This is due to the lack of fit forms of presentation of the contents of technical capacity issues of their absorption by the medical staff without the necessary back-substantive technical competence in the area.
– There is not open access to certain type of knowledge recourses. The manuals and instructions are usually stored in the unit and in the ward nurse's office, which may cause significant aggravations with their access to more people.

B. Recognition and Analysis of Knowledge Transfer

Analysis of the structure of hospital processes and related knowledge resources indicate a high degree of dispersion. Dispersion is considered at three levels:

– thematic distribution of knowledge, which is directly related to interdisciplinary of knowledge in health services and complementing the (complementarity) issues in various fields of activity,
– geographic distribution (spatial) of knowledge, which is closely linked to the dispersion of the subject, and which emphasizes the knowledge variety of specific carriers, including people,
– subjective dispersion of knowledge, which is related to certain people and organizations possessing a given part of knowledge.

Apart from dispersion, the second problematic area influencing on transfer of knowledge is the use of tacit knowledge. This kind of knowledge results from human long-term experiences, routines, individual skills and hence is hard to be codified and transferred. In the face of different competence and experience background of surgical team members it is difficult to effective communicating and understanding each other. The problem increases when surgical team consists of people representing different nationalities.

Taking part, as an observer, in hospital processes, two main ways of communication were identified:

– Form of spoken messages, either in the direct or telephone contacts.
– Written form messages, usually on paper.

Additionally two main forms of direct communication were identified:

– Verbal form, that occurs more frequently between the surgical staff and between surgeon and scrub nurse, and less between nurses and other participants of surgery.
– Nonverbal form in the shape of gestures. This kind of communication could be observed between surgical staff and scrub nurse.

In the examined hospitals no other forms of communication have been identified, in particular based on electronic mobile

devices.

The observed communication is of a large informal dimension what reflects the specifics of organizational culture in the hospital, not only in operating room. This on the one hand is significant and indicates the strong relations between the hospital staff and the so-called non-technical-interpersonal skills, very important from the point of view of the integration of activities and teamwork. On the other hand, spoken messages, which are not formal communications but spontaneous expressions, carry a number of risks related to misunderstanding and not meeting the expectations. In addition, the strong ties between workers are found but only within a given department or within a particular group of workers in the operation. Such relationship hasn't been observed among employees from different departments or hospital units, in spite the fact that they are often linked to a patient's medical history. Such a situation, in the absence of other effective forms of communication, creates the problems of repetition of the same tasks, generating the same information, and therefore lengthening surgical procedures or exposing patient to a risk.

IV. Determinants of Knowledge-Based Improving Workflow and Communication within Surgical Team

The empirical research on the essence and the ways of functioning surgical teams in the context of hospital processes helped to define the determinants of improving workflow and communication within surgical team. They are following:

D1. Surgical team is treated as a part of healthcare system consisted of healthcare organizations, people, low, medical know-how etc., the essence of which are relations between them, workflow and transfer of knowledge.

D2. Different cooperation levels should be taken into account and reflected in: (a) operative level reflected in three fundamental processes in surgical wards: preoperative, operative (surgery) and postoperative; (b) organizational level: where hospital organization is treated as a whole including organization in wards and organization in operating room.

D3. Surgical team should have opportunity to learn or refresh knowledge in range of standard procedures, messages, tools terminology, service of devices etc. during certain type of surgery,

D4. The hospital staff should have opportunity to adapt a principle: proper knowledge is used by proper people, in proper time ("just in time" and "just enough" [28]).

D5. Information should be represented in useful way i.e. by using different kind of representing methods both visual and audio which are adjusted to the knowledge absorption abilities of interdisciplinary staff.

D6. The model of improving workflow and communication is built taking into account different kind of knowledge: medical explicit and tacit, procedural and descriptive (see [29], [30].

The base for meeting the determinants is to: (a) identify and gain, (b) make representative (c) order and (d) share the knowledge resources which are essential for certain repeated tasks within hospital processes.

The ways of identify and gain (a) knowledge recourses are adjusted to certain their type:

- Video recording in the field of the surgery and other hospital procedures.
- Photographic recording of the elements of tools, devices, infrastructures used during the surgery.
- Staging and video recording of the selected "problematic" activities for example associated with communication among surgical team members, giving and taking surgical tools, assembly and disassembly of surgical tools, service of devises etc.
- Interviews with the employees (experts), recording the knowledge in the form of audio files.
- The formal recording of the procedures in the implementation of surgery.
- Analysis of the medical records.
- Analysis of the technical documentation.
- Analysis of the materials (catalogs) supplied by the medical equipment manufacturers.

Making the knowledge representative (b) it is, in turn, choosing proper form of knowledge codification. The form should be adjusted to staff perception abilities. There are following forms of knowledge representation [31]:

- drawing, e.g., sketches, photographs, diagrams, views, computer models,
- symbolic, e.g. tables and decision trees, data flow diagrams, Ishikawa diagrams (diagrams fish), ontologies,
- linguistic, e.g. a verbal description,
- virtual such as computer models, computer simulations, animations, multimedia,
- algorithmic, such as mathematical equations, parameterization, computer algorithms.

Order information (c) means to record knowledge in such a way that it will be repeatedly used depending on the contextual situation. The main assumption is here to define reusable shared content objects (SCOs) (see [32]–[36]. SCOs are perceived as elements capable of multiple sharing in different contextual situations during work processes. The examples of SCOs can be video or audio, course modules, animations, graphics, websites, PDF files, documentation, and other elements that are designed to spread certain knowledge resources.

In order to make SCOs useful in different procedures performed by different hospital staff the relations between certain SCOs have to be defined depending on terms of responsibilities linked to certain workstation. As a result the complex and personalized knowledge repository will be defined.

It is important to have proper information anytime it is needed. Responsible for that is process: knowledge sharing (d). Independent access to knowledge repository is possible through up-to-date ICT tools. The training or refreshing information (e.g. standard procedures, messages, tools terminology, service of devices) can be conducted in the place of work - in the lecture hall or in the workstation.

Using the resources in a mobile and contextual manner is

realized with help of mobile devices, and automatic identification technology data. An example of such technology is: RFID (Radio Frequency Identification) [37], [38]. It enables non-contact automatic identification and data reading using radio waves of different frequencies. This technology emerged from barcode technology.

Depending on the user privileges, RFID code triggers a specific set of information, adapted to the current needs (principle of just-in-time and just-enough). However, it was observed that the degree of absorption of knowledge, even free access to it, can be varied. For example importance for the nursing staff is acquiring the technical content knowledge. An example may be the handling of complex surgical instruments or medical device support. Given the lack of educational bases concerning technology, to acquire content of this kind is problematic (see Table I). Therefore, a method to improve the absorption of technical knowledge by nursing staff based on multimedia technologies can be appropriate. The purpose is to transform the technical knowledge in knowledge "in use", i.e., one that will enable effective and efficient use in work processes, including the maintenance and operation of surgical instruments in the operating activities. The essence of the process is to convert the traditional record of technical knowledge which, reading, requires engineering competence, in the representation of knowledge which identification and interpretation takes place in an intuitive manner, and the sharing is done in a context mode.

TABLE II
AN EXAMPLE OF IMPROVING WORKFLOW AND COMMUNICATION WITHIN SURGICAL TEAM

Det	Knowledge-based improving workflow and communication within surgical team
D1	Certain surgical team members has access to personalized information about: - patient (important for A, S, N in advance, needed to prepare patient to surgery) - availability of tools, devices, hospital infrastructure etc. (important for S, SN in advance, needed to plan surgeries, check and prepare surgical equipment) - availability of staff members (important for S in advance, needed to plan surgical teams consists of harmonious team)
D2	Certain surgical team members has access to personalized information about: - procedures, training materials, check lists etc. according to type and stage of processes (important for everyone, needed to refresh knowledge) - legislative and regulations (important to everyone, needed to do tasks according to low) Staff members has opportunity to maintain communication via ICT tools
D3	Surgical team has access to knowledge repositories any time it is needed
D4	Surgical team members has access to personalized contextual information due to use of ICT tools
D5	Information is represent in a way which is adjusted to perception abilities, mainly: video and audio
D6	Knowledge is identified, gained and ordered using SCOs according to assign to types: explicit and tacit, procedural and descriptive.

The proposed determinants (Det in the first column in Table II) of improving workflow and communication within surgical team are illustrated in the example of surgical teamwork during laparoscopic surgery: cholecystectomy (Table II). Described situation concerns service of surgical instruments.

V. CONCLUSIONS

The objective of the article was to describe a mode of how to timely and accurate transfer of information so as to surgical team members can effectively and efficiently coordinate actions during surgical procedures. Thanks to use of SCOs and ability to access to reusable information there is possible to maintain patterns standards of actions and hence to avoid errors. Despite the high rotation of medical staff it is possible to cover the best practices due to codify tacit knowledge and share them using ICT tools.

The study introduces a new challenging development on the way of improving work comfortable of surgical teams, as well as improving healthcare and patient safety.

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