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INNOVATION SCENARIOS FOR THE TECHNOLOGICAL DESIGN OF THE OPERATING SUITE: DESIGN CRITERIA AND METHODS

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Today the operating suite is considered, together with the diagnostic unit, the functional area that is more subject to profound changes, resulting in an increased technological complexity. The road paved by the new approaches to care and illness imply that the coming years will be characterized by a profound and radical change of the medical-scientific knowledge and even more so of the diagnostic and therapeutic methodologies. This paper analyses the characteristics of existing healthcare facilities, with respect to the needs created by the new role of the hospital, as well as the impacts on the more complex and rapidly changing sectors. The identification of the problems and the definition of the number of needs will allow to outline the strategies to adopt for the design of a modern operating suite, defining the basic requirements for an optimum supply of the service. The objective will be to define useful design criteria and methods to favour the inclusion process of innovative factors, so that the building unit can promptly respond to any evolution of needs, overcoming the now consolidated spatial and functional obsolescence that has characterized it lately.

Keywords: Obsolescence, Changeability, Innovative factors, Flexibility, Quality.

1 TRENDS

In time, the hospital has been redefined and divided into three main spatial-functional sectors: ward, diagnostic services and treatment and general services. In each hospital, the weight of these three sectors has changed with the passing of time. If on one hand the introduction of new medical practices and innovative biomedical equipment has allowed for the reduction in the number and duration of hospital stay, on the other hand the new management models have allowed for the outsourcing of many general services, with the resulting reduction of these two sectors. In parallel, the diagnostic and therapeutic sector, under the strong impulse of the new technological opportunities, on the contrary has suffered from the opposite, with resulting complication and remarkable increase compared to the other two (Figure 1) (Stocchetti and Rossi Prodi 1992). The diagnostic and therapeutic sector, therefore, is the functional area that is subject to the more rapid and radical changes; additionally, the break of traditional relational constraints between the different functional areas results from the technological innovation in the medical field, one of the main factors of advance and development in the redefinition of the spatial and technological structures of the entire hospital system, so that it becomes a hub of excellence in the supply of the national healthcare services (Giofrè 2002).

The set of changes under way requires to reconsider and rethink the hospital as a high-technological complexity building unit, structurally and organizationally conceived to be

managed as a high-efficiency system, with clear regulatory and performance-related requirements.

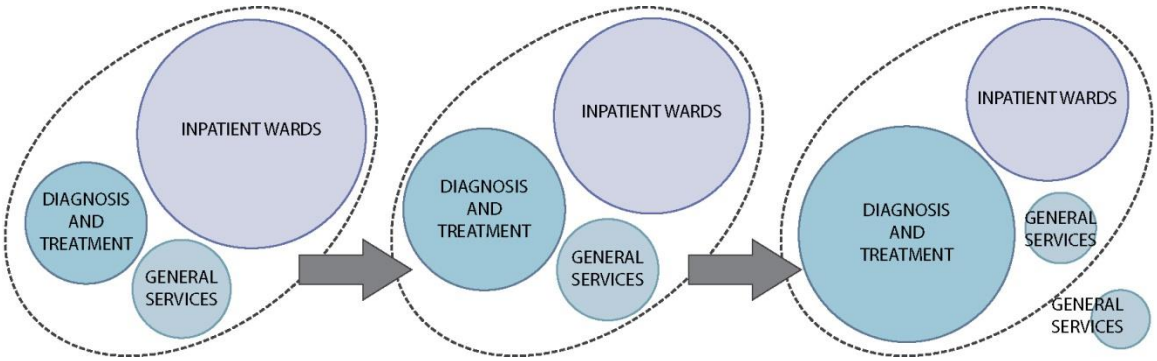

Figure 1. Evolution of the functional areas inside the hospital.

In this respect, the scientific community has lately often wondered about the direction in which the hospital will be evolving in the near future, but the complexity and quantity of the factors involved is so high that we cannot contemplate likely scenarios. However, an attempt is being made to identify some common trends which characterize the design of modern hospitals, mainly by examining some advanced American healthcare facilities in which the specialist hospital model is represented by a very high-technology, high-care facility, with a small number of beds and short stays, with easy communication to promote the coordination of doctors, staff and patients and with close integration with research. This integration becomes increasingly important since an increasingly personalized prevention policy, made possible by the new medical breakthroughs (think about the recent discovery of the human genome), has become more widespread. Now in fact it is not just possible to take differentiated action on each individual patient, but also to anticipate the likely outbreak of a pathology, being able to take care of a disease-prone subject before the disease appears (Carabillò 2012).

The evolution of surgery also adds to these changes; in recent years, it has been so impressive as to envision an actual revolution, not just of techniques, but also of the reference cultural models, determining a shift from a tissue-destructive surgery to an increasingly conservative and, depending on the cases, reconstructive surgery.

This shift has allowed for the establishment of a less invasive and bloody internal surgery, made possible by the use of natural entryways to the surgery area (canals and vessels) or increasingly small penetration tools (laparoscopes and probes). These performances are made possible by a rapidly growing technology, creating and managing the images, creating new modes of acting on organs and tissues, now also remotely and with laser or targeted radiations. If the establishment of digitalized communication technology is changing many reference elements, including physical ones, since virtual reality makes remote surgery possible, with yet-to-be-explored development opportunities, robotisation starts supplying self-sustaining tools for the performance of complex surgeries and miniaturization leads to nanotechnology, with brand new and broad access and surgery potentials.

All this inevitably changes the reference characteristics in which surgery is performed, and what is defined operating block, with the different organizational and service components, needs to adjust as rapidly.

2 DESIGNING THE OPERATING SUITE

The factors characterizing the reference scenario are an essential input when compared to the proven obsolescence of the Italian healthcare system, with reference to the needs created by the new role of the hospital; such an obsolescence inevitably negatively emphasizes those sectors that are directly affected by the constant innovation process. With reference to the spatial and technological obsolescence of hospital units, the operating suite is a heavily problematic area since it requires a more extensive thorough reflection on architecture research in order to determine useful design criteria to implement spatial and technological innovation, also understood as the capacity of a building unit to promptly react to the potential evolutions of needs, through its internal and external *flexibility* and *changeability*. The design of an operating block that is fit to the challenges of the progresses of medical technologies today is a complex process, resulting from distinct fields of specialist knowledge, a design process that systemically creates a relationship among all the functional, structural, plant, technological, ergonomic aspects that contribute to the determination of the environmental quality of the building unit. In view of the pursuit of an adequate design of the operating suite, a renewed vision of the design process imposes itself, implementing innovation through the adoption of useful methods and tools to favour the approach of such complexity.

The design of the operating block requires a unit vision of what will be the future structural and organizational structure of the entire hospital, since it is an actual *technological box*, whose location and size firstly derive from a careful analysis of the costs of construction, management and from the organizational choices that such choices may imply. Additionally, the growing focus on sustainability, also in such a specialist field as the operating room, translates in the implementation and evaluation of important design inputs such as the correct sizing and positioning of the surgical block to favour its durable management, the comfort of the rooms, the control and periodical maintenance of materials.

The *positioning* of the operating suite inside the hospital facility is an aspect characterizing the rationality and efficiency of the service, for which a correct evaluation is necessary, in order to guarantee a quick and easy connection with the closely connected functional areas, whose relationships are in general identified on the basis of the main traffic flows, and far from pathways that are not typically relevant to the suite, so as to avoid any interferences with the external services (Figure 2).

An additional important criterion is locating it in a position that is not squeezed between services that are hard to relocate to other hospital areas, ensuring easy and quick changes and expansions in time (Carabillò and Manara 2010). In this respect it is necessary to stress that inside the operating room the increasingly widespread use of MRI equipment supporting surgery (hybrid operating room) is not only changing the spatial and technological characteristics of the suite, but will also lead to greater diagnostic independence, breaking the traditional ties between these two functional areas. Likewise, the constant evolution of robotic-assisted surgery and computer-assisted surgery, will allow for remote handling, up to the use of completely independent robots, controlled by a surgical operator, assuming a future delocalization of the control station together with the operating suite staff. Even if these innovative factors can only currently cover some limited fields of activity, they evolve quickly; that is why it is important that the design implements such trends from the very early stages, also in order to avoid downsizing in short terms.

The *size* of the suite, whose main parameter is the number of operating rooms, is the more critical aspect and as such it requires careful planning based on the number of surgeries, their duration and type; the functioning of the rooms, the number of hours and days in which the

operating rooms are used; the relationship between surgery in-patients and out-patients; the number of intensive therapies compared to the number of surgical patients; the development of the technologies directly involved in the evolution of the surgical sector, both in terms of organization-management, and as concerns the aspects that are more connected to design, i.e. layout and size. If you consider the operating room as the elementary unit of the sizing, it is necessary to consider a space at least 2.5/3 times the area of the operating room for the storage areas required for the storage of material and moving equipment (Pedrini 2010). An operating group of two operating rooms covering a surface of 40 sqm each has a service perimeter ranging between 580- 600 sqm (minimum assessment) (Ciarolo and Giofrè 2014). Such storage areas/rooms revolve around the operating room instructing different layouts, organized in sequence of sterility from the entrance door to the operating room (Figure 3), in which you reach the highest level of sterility.

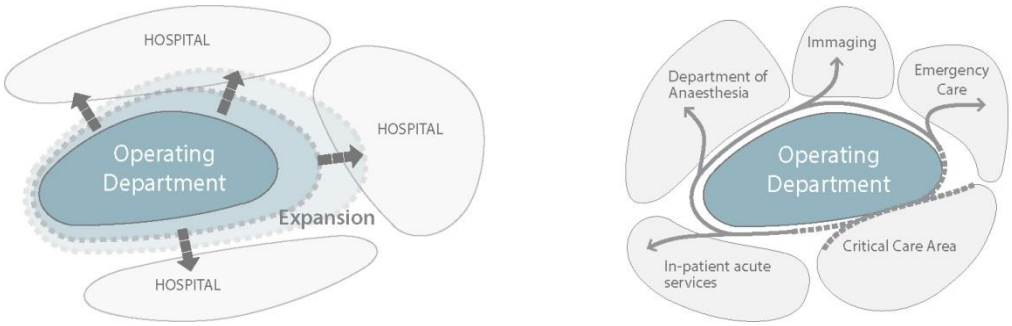

Figure 2. Criteria for the positioning of the operating suite.

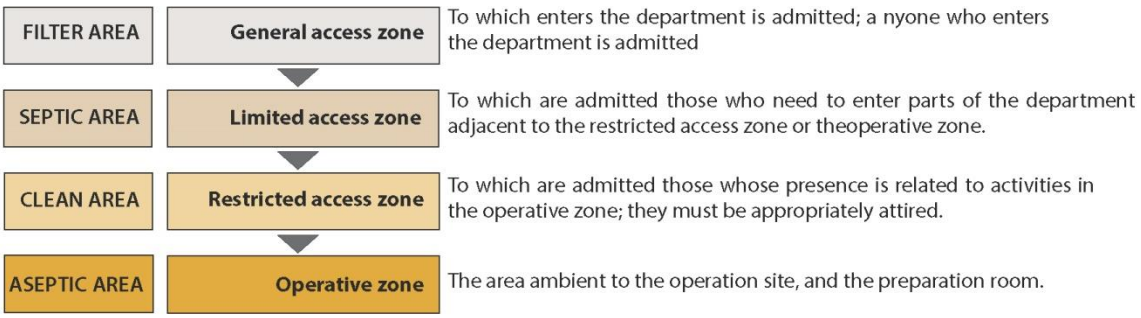

Figure 3. Aggregation criteria of the environmental units inside the operating suite.

One of the best models, that is currently being adopted in the United States is the so-called *cluster, pod or modular*, consisting in the aggregation of a limited number of operating rooms around a central area from which the sterile material directly passes through sliding doors or windows. Each operating block is made up of a variable number of between three and five modules and is served by a peripheral corridor. This layout has granted remarkable advantages in terms of sterility, but especially in terms of flexibility of the plants (also in view of future expansions) and adaptation to the different spaces, thanks to the possibility of developing different modes of aggregation of the various modules (Carabillò and Manara 2010).

In the long term the definition of the suite layout, despite not showing any clear changes from the models proposed in recent years, will be subject to heavy technological innovation. However, since it is not possible to predict technological evolutions and resulting functional and plant

requirement in such a long period, as suggested by Cambieri and Leongrande, it is worthwhile to keep an “open” design, suggesting the construction of an oversized operating room (from 60 to to 80 sqm) every 4-5 new "standard" operating rooms, not necessarily dedicated to a special technological innovation, but simply susceptible to accommodating one in the future.

The *sizing of the operating rooms* is in fact one of the most debated aspects, in relation to the possibilities offered by the new technologies and to the new surgeries. The area of an operating room varies on the basis of the type of surgeries, the total number of medical staff and in particular the size of the equipment (Figure 4).

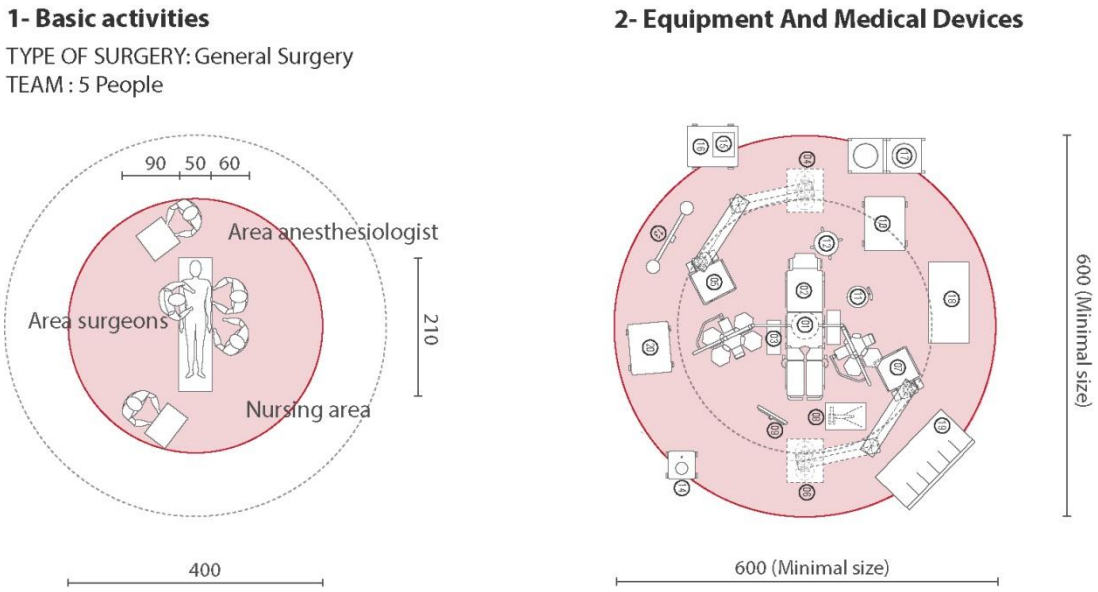

Figure 4. Criteria for the sizing of an operating room of general surgery.

For example, in many state-of-the-art facilities in the United States, the average size of a room is of 60 sqm, with size ranging from 70 to 80 sqm if special technologies, like the MRI, are needed close at hand; while the Anglo-Saxon manuals indicate sizing criteria ranging depending of the speciality of the surgeries, from 46 to 72 sqm. Italian legislation, on the contrary, provides for a minimum standard of 36sqm, varying depending on the Regions, between 30sqm for medium-complex surgeries and 40sqm for high-complex surgeries, well below the above-mentioned values, anything but state of the art. One may say that the trend is to build a *universal operating room*, with resulting great organizational and managerial advantages, able to support surgeries of the different specialities and a large technological equipment, whose standard is of 45-55 sqm. Such a parameter is an important structural and technological requirement, that should be considered when giving the global definition of the design (from architecture, plant, biomedical technologies, etc.). In the design process the structural and technological characteristics represent in fact essential quality requirements, since they concur in the determination of the final outcomes of the services supplied.

3 CONCLUSIONS

The progress connected with telecommunication , digital imaging and robotic, that permit the spread of the new surgery techniques, have imposed the introduction of new equipment in

operating room, which are innovative and the same time cumbersome, requiring too much technological and organizational improvised solutions, that more often than not are unable to resolve ergonomic and spatial problems connected to surgical operativeness: this represent one of failure factor of the process of introduction and spread of new technology in the healthcare sector. So, design practice needs to be based on perfect running of planned organization, keeping on mind all the technologies that will be used at most of their capacity, by an intelligent inserting.

This will require a detailed analysis of *plant requirements*, *structural* (related to the structural aspects and to their obsolescence level or constraints imposed by current plants) and *technological ones* (related to size and way to use of equipment and introduction of support technological systems), with the aim to assure their perfect integration, improving security and efficiency of working process and then, the quality of performance given to patient.

Finally, although some trends are predictable and recognizable in the medium and long term, the uncertainty due to unexpected evolutionary developments, makes it necessary to insert the concept of flexibility as essential design data.

Spatial and technological flexibility, developed in parallel to plant flexibility (with special reference to mechanical plants), today is the direction to follow so that the suite is conceived as an integrated system, guaranteeing at the same time safety, functionality, environmental hygiene and comfort, as well as the long-term preservation of such requirements, thus ensuring a high level of clinical and performance quality.

References

Carabillò, M., Quali ospedali per il prossimo futuro?, *Progettare per la Sanità*, Bema Editrice, 125(1), 24-25, March, 2012.

Carabillò, M., and Manara, G., La progettazione architettonica e impiantistica, in *Il reparto operatorio. Progettazione, organizzazione, controllo*, Cambieri, A., Girardi, F., D'Alfonso, M., Luongo, A., and Bock, M. (eds.), 27-28, Il Pensiero Scientifico Editore, Rome, 2010.

Ciarolo, F., and Giofrè, F., *Sala operatoria e Terapia intensiva. Dalla pratica medica al design per la prevenzione delle infezioni*, Maggioli Editore, Santarcangelo di Romagna, 2014.

Giofrè, F., Innovazione nel progetto della aree ad elevata complessità tecnologica, in *Ergonomia e ospedale: valutazione, progettazione e gestione di ambienti, organizzazione, strumenti e servizi*, Baglioni, A., Tartaglia, R. (eds.), 52- 78, il Sole 24 ore, Milan, 2002.

Pedrini, D., L'architettura della sala operatoria: sostenibilità ambientale e vivibilità degli spazi, in *Il reparto operatorio, Progettazione, organizzazione, controllo*, Cambieri, A., Girardi, F., D'Alfonso, M., Luongo, A., and Bock, M. (eds.), 57-58, Il Pensiero Scientifico Editore, Rome, 2010.

Stocchetti, A., and Rossi Prodi, F., , *L'architettura dell'ospedale,* Alinea, Florence, 1990.