

Philosophy of Medicine

Perspectives

Skills, Scalpels and Robots: The Surgeon as Technician

Olivier Del Fabbro

Department of Humanities, Social and Political Sciences, Chair for Philosophy, ETH Zurich, Zurich, Switzerland.

Email: olivier.delfabbro@phil.gess.ethz.ch

Xavier Muller

Department for Surgery and Transplantation, Croix Rousse University Hospital, Hospices Civils de Lyon, Lyon, France.

Email: xmuller.ucl@gmail.com

Abstract

According to Aristotle, medical practice relies on practical knowledge to care for individual patients. This is especially true for surgery, where the surgeon directly acts on a patient using not only technical skills but also acquired experience. We first describe the surgeon's technical activity, which is directly linked to surgical tools and their historical evolution. Second, given that surgical activity aims at treating patients, we analyze which techniques and concurrent knowledge the surgeon must rely on to perform successful surgical operations. These characteristics are analyzed by using concepts from philosophy of technologies by André Leroi-Gourhan, Gilbert Simondon and John Dewey.

1. Introduction

Already for Aristotle, medical activity was based on practical knowledge (*phronesis*); firstly, because it depends on individual and singular cases and, secondly, because it aims to maintain the individual's health: "But as there are numerous pursuits and arts and sciences, it follows that their ends are correspondingly numerous: for instance, the end of the science of medicine is health" (*Nicomachean Ethics* 1094a7–9). In contrast to the rather theoretical knowledge of philosophy, which is occupied with finding the most abstract and fundamental principles, medicine is orientated towards practicality. Neither first nor eternal principles are of help to the physician, only practical knowledge about the individual patient.¹

¹ In this context Werner Jaeger (1957, 55) writes: "One cannot escape this objection, Aristotle says, by saying that of course the physician is not concerned directly with the idea of 'good itself'—in its full universality—but with 'health itself', i.e. with the essence of health, for he is interested exclusively in human health, or rather in the health of this or that patient, since he has to cure people individually." For a description of medicine and its relation to philosophy in antiquity, see Frede (1986). Daniel E. Hall argues for surgical activity to be based on the Aristotelian *phronesis* (Hall 2011). He neglects, however, the important role of technics and technology,



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We believe that such a definition of medicine—practical knowledge and the motivation of the patient’s health—can be transposed to today’s surgical activity. In this sense, the surgeon is “licensed by society to physically assault patients” (Fischer 2005, 260) and “to cure by means of bodily invasion” (Gawande 2012, 1716), with a potentially fatal outcome for the patient. Surgical knowledge therefore requires a pragmatic approach since it is situated between theory and the direct action on a patient.

Such action on the patient, however, depends on the manual use of technical tools and machines. In contrast to other medical disciplines—for example, radiology, which also relies on new technical inventions, such as artificial intelligence (Langlotz 2019)—surgeons and their tools present a special field of technical activity from the perspective of human-machine interaction (Liggieri and Müller 2019).

This article consecutively addresses the following topics based on philosophical concepts from Gilbert Simondon, André Leroi-Gourhan and John Dewey: (1) An introduction to the philosophy of technology of Simondon, Leroi-Gourhan and Dewey for better contextual understanding; (2) surgical activity as a specific type of technical activity; (3) the historical evolution of surgical tools; (4) the surgeon involved in the invention of novel technical objects; and (5) the surgeon’s technical activity with regard to theoretical knowledge and practical action. With these five topics in mind, it is worth highlighting and reflecting upon the different aspects of surgery from a philosophy of technology perspective because this differs from scientific and evidence-based medicine perspectives of surgery.²

2. The Philosophy of Technology of Simondon, Leroi-Gourhan and Dewey

The theoretical background of our work is based on the philosophy of technology of Simondon, Leroi-Gourhan and Dewey, with special emphasis on the concepts of technical objects and invention.

Simondon is known for his concept of the mode of existence of technical objects (Simondon 2017). Methodologically, Simondon’s own collection of technical objects that he opens for inspection plays an important role here. He analyzes objects such as combustion engines, vacuum tubes and telephones. What Simondon observes mainly is what he calls the concretization process. Take, for example, the cooling fins of a combustion engine. First, the fins have one main function: cooling. While the engine runs, Simondon observes that the fins also play a mechanical role of support. One structure—the cooling fins—thus plays two functions or operations, as Simondon also says. Thus, the object becomes more concrete because structures and operations coalesce. The concretization process is in this sense a question of degree, meaning that the more structures and operations merge, the more the object becomes viable for autonomous existence. Moreover, because in concrete objects the individual structures all work together intimately to the point that almost no secondary undesired effects are present, they are very close to natural objects and yet not identical to them.³ Technical objects only tend towards the process of concretization, while natural objects are always already concrete. In other words, technical objects are not capable of inventing themselves. They certainly have the capability of operating autonomously to a certain extent and show within their mode of operation a variation of behaviour, but they

which we would like to highlight in this article. For an interpretation of medicine as an art and not an evidence-based scientific enterprise, c.f. Steurer (2019).

² This topic is discussed by highlighting, for example, the concept of the surgeon-scientist; see Kibbe and Velazquez (2017); Keswani et al. (2017); Henke and Mulholland (2017).

³ Simondon is here very close to Georges Canguilhem’s philosophy of life (Canguilhem 1992).

are not capable of completely re-inventing themselves. From the viewpoint of human-machine relations, there is consequently a need at the normative level for an inventor, who not only comprehends the object in its concretization process (its genesis and construction), but also anticipates the operative structures of the object. The technical interaction of humans and machines is to be sought in the relation between inventor and technical object, which refers to the relation between the way of functioning of the object and the process of inventive thinking: “The dynamism of thought is the same as that of the technological object” (Simondon 2017, 60).

As an archaeologist, paleontologist and anthropologist Leroi-Gourhan is also interested in collecting technical objects and opening them up for inspection. In contrast to Simondon, however, his main focus lies in prehistoric objects (Leroi-Gourhan 1971, 1973). Simondon (2014, 33) explicitly refers to Leroi-Gourhan with regard to his own analysis of objects, thereby highlighting that a shift from prehistoric to industrial objects is needed.⁴

Leroi-Gourhan distances himself methodologically from his teacher, Marcel Mauss (Schlanger 2020). The goal is to focus on objects and their classifications; that is, their functionality and materiality, not on body techniques. Two theoretical concepts play an important role here: tendency and fact (Leroi-Gourhan 1971). Whereas tendency is abstract, inevitable and linear, and describes how technologies reoccur over time and at different places, facts are concrete and particular, and related to multiple milieux, such as internal (politics, religion, language), external (geography, zoology, vegetal) and technical. Tendency and fact are in the end two aspects that form together the evolution of technical objects. Mutation of objects within evolution in turn is based on technical usage and especially inventions by groups, which are constantly looking for more effective techniques and technical objects based on the conditions of internal and external milieux or the influence of other groups. Hence, for both Simondon and Leroi-Gourhan, the analysis of objects shows a certain historical evolution of technical objects and the way they change over time—in both structure and operation.

Whereas Simondon and Leroi-Gourhan enable us to conceptually grasp functionalities, structures and inventions of technical objects themselves, the pragmatism of Dewey allows us to focus on usability and knowledge. The first important point to make is that knowledge starts from usage and, more importantly, from habits; that is, repetitions of actions of some form. The initiation to habits occurs at a very young age (Dewey 2008a). Second, once such habits are blocked or encounter an obstacle, reflection as deliberation arises and allows us to imaginatively reorient an action. Lastly, judgement allows us to evaluate and foresee the consequences of a possible outcome. So, whereas the concept of habit allows us to describe how and what skills individuals acquire, judgement describes how new skills possibly emerge.⁵

The sections that follow show how these concepts of mode of operation and structure of technical objects, invention and habit-deliberation by Simondon, Leroi-Gourhan and Dewey are applicable to surgical activity.

⁴ For systematic and conceptual influences and relationships between Leroi-Gourhan and Simondon, see Guchet (2008) and Del Fabbro (2019).

⁵ Here the difference made by Gilbert Ryle (1946) of *knowing that* and *knowing how* is close to what Dewey says and what we intend to show, even though our focus lies, due to the relation to Leroi-Gourhan and Simondon, more on objects, in this case surgical objects, and the concrete habits involved. This object- and habit-orientated perspective focuses primarily on the description of concrete practices and technologies and not on the discussion of technological knowledge in general. For a thorough overview, see Houkes (2009).

3. Surgical Activity as Technical Activity

Historically, medical doctors were not allowed to act directly on patients. In its classical formulation the Hippocratic sermon states: “I will not use the knife, not even, verily, on sufferers from stone, but I will give place to such as are craftsmen therein” (*The Oath* 22–24). In line with the Hippocratic sermon, Galenic medicine distinguishes between a theoretical application of medical knowledge, practised by physicians and a practical medical action, referred to as surgery (Gawande 2012, 1717). This differentiation was still made in the sixteenth century, when surgical interventions were not performed by physicians, but by barbers. In 1537, a barber-surgeon named Ambroise Paré operated on wounded soldiers during the siege of Turin and thus was constantly in direct contact with human suffering. After having realized the difficulties related to pain management during battlefield surgery, Paré developed and published new pain-sparing surgical techniques (Drucker 2008, 201). Likewise, the ability to alleviate pain and subsequent suffering of the patient through the developments of anaesthesia and antiseptic practices by surgeons greatly influenced the progress of surgical techniques by allowing longer and more complicated surgical interventions (Gawande 2012, 1718). These technical achievements made surgery a prominent field of medical practice in the nineteenth century. In 1862, 50 per cent of the publications in the renowned *New England Journal of Medicine* were authored by surgeons (Gawande 2012).

This short historical anecdote shows that in surgical practice both surgical tools and the surgeon as technician play an important role. The importance of tools in the overall development of human evolution is described by Leroi-Gourhan (1993), who claims that walking upright enabled hominids to use their hands in order to manipulate all sorts of materials, which finally led to the development of tools. These tools (for example, a primitive hand axe), together with the technical skills required to manufacture and use them for a specific purpose, are defined as technical activity. Creating primitive surgical blades by knocking off splinters from a mineral with a stone graver can be compared to the process of creating a primitive hand axe by using a sharp stone (Kirkup 1995, 381). Hence, the surgeon engages in what Leroi-Gourhan calls technical activity.⁶

Furthermore, while surgical tools undergo a specific evolution similar to other technical objects; that is, from primitive knives formed out of stone to modern ultrasonic scalpels, (Kirkup 1993, 1995), the interaction between the surgeon, as the subject, and the tool, the technical object, has not changed. The modern surgeon still uses a scalpel to operate, even though ultrasonic waves are used for dissecting. Thus, surgical activity remains to this day a technical activity determined by the relationship between the surgeon and the surgical tools.

It is important to highlight that in technical activity, technical objects are not passive entities with the sole purpose of being used by active subjects. Rather, subjects and objects are both active in that they influence each other’s activities reciprocally. The mode of operation of the tool determines the type of operation that is performed during surgery. For example, in open surgery a simple scalpel is used, while laparoscopic surgery requires specific tools, such as a camera, trocars and a grasper. This in turn forces the surgeons to have specific skills in order to perform certain types of surgical interventions, which might possibly change the mode of operation of the tools themselves (Krawczyk 2017). We return to this topic in sections 4 and 6.

⁶ With regard to Leroi-Gourhan’s relationship to philosophy of technology, see Schlanger (2020).

4. The Evolution of Surgical Tools as Actualization Process

The evolution of surgical tools, together with the evolution of the skills of the surgeon, can be defined as a constant actualization process, in which new tools are integrated into surgical activity.⁷

A recent result of this actualization process is the surgical robot. The surgical robot used nowadays is based on the integration of three technical components; namely, light source, video visualization and ergonomics (Mack 2001). Historically, the invention of the electric light bulb by Thomas Edison in 1879 enabled the surgeon to bring “light into the internal cavities of the body” (Nezhat 2003, 1). Combined with a complicated lens system, the internal anatomy of the human body could be visualized without having to perform major incisions. In addition to better visualization, specific surgical tools were developed to perform operations through very small skin incisions without having to touch the organs. Altogether, this led to the first laparoscopic procedures in the early 1930s. However, even though visualization was improved, open surgery and laparoscopic surgery were limited by dexterity. For example, a surgeon’s hand can only perform a rotation of 180 degrees and is thus limited when operating in confined spaces, such as the pelvic space. Furthermore, subtle manual movements (as required, for example, in vascular surgery) are prone to be affected by trembling. If a surgeon performs a very small suture on a major blood vessel using a 1millimetre needle, trembling reduces his capability to perform a good suture. To overcome these dexterity problems, robotic tools were developed, consisting of a simple robotic arm holding an instrument in order to reduce trembling. Nowadays, the modern surgical robot is able to perform 360-degree rotations, which, combined with enhanced visualization, culminates in the concept of telepresence; that is to say, the surgeon performs the operation using a console as a remote control while having a 3D image of the operating field. Ultimately, telepresence is the major contribution made by robotic surgery to laparoscopic surgery.

However, the technical advancements of the robotic system are not suited for every type of operation. Conventional suturing, for example, is easier in laparoscopic or open surgery, due to the absence of tactile feedback in the robotic arms. Lastly, the technical characteristics of operating with a surgical robot, such as the use of a camera, handling instruments in a confined space, using joysticks or working in a restricted field of vision, show that the surgical skills required to perform an operation with a robot are different from those required for an open operation. Moreover, the actualization process in the field of surgery leads to new technical objects, in this case the surgical robot, which also changes surgical activity as such.⁸

5. The surgeon as inventor

One important role in the actualization process is played by technical invention. The inventor anticipates the evolution of technical reality and introduces new technical objects, thereby creating new expressive modes of technical activity. We take our definition of technical invention from Simondon (2017, 74), who describes invention as mainly being the

⁷ In his presidential address to the European Surgical Association in 2017, Marek Krawczyk (2017, 703) highlights the interaction between surgeons and their surgical tools: “Technological development helped us to perform various operations and offer better therapy but forced us to change our approach to the art of surgery. We had to adapt our manual dexterity in order to operate new equipment, and thus to be able to perform, among others, minimally invasive surgery.”

⁸ Concerning the actualization process of technical objects, Leroi-Gourhan (1993, 245) writes: “Actions of the teeth shift to the hand, which handles the portable tool; then the tool shifts still further away, and a part of the gesture is transferred from the arm to the hand-operated machine.”

inventor anticipating the technical realm surrounding him/her in order to construct new modes of operation in technical objects: “The inventor does not proceed *ex nihilo*, starting from matter that he gives form to, but from elements that are already technical, with respect to which an individual being is discovered as that which is susceptible to incorporating them.” Simondon’s definition of technical invention is thus in line with Leroi-Gourhan’s definition of technical evolution of technical objects, which is based on the reciprocal interaction between the creating subject, a technician and the technical object. In other words, an inventive technician, who performs a technical activity, might also develop new technical objects by anticipating the functionality of already existing technical objects. This anticipation ultimately leads to a constant actualization process, in which new technical objects are integrated into general technical evolution as such.

Even though surgeons are not known for being inventors, historically there are many surgeons who invented new technical objects in the field of surgery. One of these surgeon-inventors is Alexis Carrel. Born in France in 1873, Carrel is known for the development of vascular sutures and patches, for which he received the Nobel Prize in 1912 (Dutkowski, De Rougement and Clavien 2008). Failing to receive a faculty position in France, Carrel emigrated to Montreal and later to Chicago and then to New York, where he worked at the famous Rockefeller Institute. During his time there, Carrel switched his focus from vascular suture techniques to tissue culture and organ perfusion techniques. His aim was to create technical devices that could maintain organs alive outside of the body (Dutkowski, De Rougement and Clavien 2008, 2000).⁹ It was his encounter with the famous aviator and engineer Charles Lindbergh that led to probably one of the most interesting collaborations between two technicians of different realms: surgery and engineering.

Their vision was to build a device that could keep organs alive outside of the organism by perfusing them with blood. Together, they built a perfusion machine out of glass, with several chambers connected by tubes (Carrel, Lindbergh 1935). By placing the organ in one of the chambers, it could be perfused by blood serum enriched by amino acids (Dutkowski, De Rougement and Clavien 2008, 2000). Gas insufflation simulated the heartbeat and assured fluid flow through the perfused organ. Although Carrel and Lindbergh experimented only on animals, their first results were astonishing: “Thyroids were amazingly well preserved with pulsating arteries after a period of up to 30 days. ... Cat hearts maintained their contractions for about 12 hours” (Dutkowski, De Rougement and Clavien 2008, 2001). This shows that the perfusion pump itself was highly complex and its functionality was proof of the inventive skills of both men. The technological principle of Carrel’s perfusion machine has since been further developed and is currently used in solid organ transplantation (Schlegel, Muller and Dutkowski 2017). In other words, the pump has undergone a continuous actualization process from Carrel through to the present day.¹⁰ The example of Carrel’s perfusion machine shows that the surgeon does not only use surgical tools in a simple utilitarian way, but actively contributes to the actualization process of the tools as an inventor. As Simondon (2017, 18) concludes, tools and machines contain the inventor’s reflection: “Man’s presence to machines is a perpetuated invention. What resides

⁹ Carrel’s attempts go back to his obsession with finding the secret of life, by making the distinction between an active and latent life form. The distinction actually goes back to the famous physician Marie François Xavier Bichat. Interestingly, Carrel’s distinction is still used in today’s transplantation surgery. The above-mentioned latent life form can be divided into two parts: one process being a normal progress towards death, another process being a state in which vital processes are suspended. Organ donation after cardiac death still relies on this distinction, since after a patient’s cardiac death, cellular death of organs is a slower process, enabling transplantations (Dutkowski, De Rougement and Clavien 2008).

¹⁰ Another example of a recent and fruitful collaboration between surgeons and engineers can be found in the paper by Dilmurodjon Eshmuminov et al. (2020), which describes a perfusion machine enabling *ex vivo* preservation of human livers for one week.

in the machines is human reality, human gesture fixed and crystallized into working structures.”

From these historical examples of surgical activity, we can conclude: (1) Surgical tools are part of an actualization process like any other technical object; (2) consequently, the surgeon can be seen as a technician; and (3) the surgeon does not only use these tools, but also contributes to their actualization by technical inventions.

6. Surgical Knowledge as Technical Knowledge

The surgeon is a practitioner similar to any other physician in that he treats patients suffering from a disease. However, as we have shown in the preceding sections, the specificity of a surgeon’s practices is strongly connected to technical activity, technical evolution and technical invention. Hence, as surgical operations are mediated through technical objects, the surgeon must rely on technical knowledge, if his/her surgical operations are to be successful.

Dewey distinguishes between actions guided by habits and actions guided by deliberation (Dewey 2008b). Whereas habits are socially acquired dispositions of individuals with particular activities and responsive attitudes towards an environment, deliberation is the need to reflect, which arises when a repetitive habit is blocked. In other words, with habits, the same means are used to accomplish the same ends over and over again. Notice that, even though habits are repetitive, it does not mean that they are passive. Rather, following habits means to possess certain skills: “Habits are arts. They involve skill of sensory and motor organs ... They require order, discipline, and manifest technique” (Dewey 2008b, 15–16). Deliberation, however, implies reflection on problems that arise when repetitive action is not possible (Dewey 2008b, 132). Hence, because deliberation is the imagination of possible reorientations of an action in a problematic situation, a decision or a choice has to be made, which will impact on the outcome of the situation itself: “We want things that are incompatible with one another; therefore we have to make a choice of what we *really* want” (Dewey 2008b, 134). But, since taking a decision means to choose out of a plurality of possible options, there is a potential freedom of judgement: “We judge present desires and habits by their tendency to produce certain consequences” (Dewey 2008b, 143). For Dewey, judgements give a significance to habits and dispositions because they evaluate the action in the present with regard to its possible outcome.¹¹

We now turn to the conceptual distinctions between habit, deliberation, decision and judgment proposed by Dewey with examples from surgical practice: (1) Surgical activity is bound to a learning process guided by repetition; that is, the learning curve shows how surgical performance tends to improve and become a habit; (2) situations can arise in which trained surgical habits are blocked; for example, as a result of a patient’s anatomical disposition; (3) upon such blockage, techniques as means can be modified deliberately through decision-making during surgical interventions. The pursued end (the well-being of the patient, which socially legitimates surgical bodily invasion) in turn orientates judgement and procures significance to the technical activities (Fischer 2005, 260).

In a comment published in the *Lancet* in 1925 titled “The Surgeon as a Technician”, the authors state: “With the perfection of anesthetics and of asepsis, the urgent necessity for [such] manipulative dexterity and speed has gone”, but, they add, the surgeon should not forget “that it really does matter how an operation is performed” (1925, 657). The main component of surgical knowledge remains “an accurate knowledge of anatomy and a precise

¹¹ With regard to a freedom of choice within Dewey’s philosophy, see Levine (2015). Larry Hickman (1990) has shown that Dewey’s work can be interpreted from a philosophy of technology perspective.

conception of the projected steps”. The principal challenge in 1925 (and today) is “the difficulties in obtaining the experience thus necessitated” to be able to perform a surgical technique safely.

This notion, referred to as the learning curve, is particularly prominent in the context of the introduction of a novel surgical technique for a complicated surgical intervention. An example vigorously discussed among surgeons today is the use of a minimally invasive approach (laparoscopic or robotic approach) to perform a pancreatoduodenectomy (Van Hilst et al. 2019). This operation consists in removing the duodenum and the head of the pancreas and is mostly performed for pancreatic cancer situated in the head of the pancreatic gland. Two particularities should be noted: first, the duodenum and the pancreas are situated in the posterior compartment of the abdomen and are in close contact with major blood vessels, which present a major risk of bleeding. Second, after removing the duodenum and the pancreatic head, the continuity of the digestive system needs to be restored, forcing the surgeon to perform three new connections between (1) the bile ducts and the intestine, (2) the stomach and the intestine and (3) the tail of the pancreas and the intestine. Altogether, the posterior position, the need for blood vessel resection and restoring the integrity of the digestive system by three different sutures make this operation very challenging from a technical point of view. While all these steps are standardized in the open approach—where a large abdominal incision is performed to gain access to the duodenum and the pancreas—they may present an additional difficulty during the laparoscopic approach. Some of these difficulties are the restricted visual field because of the use of a camera instead of the surgeon’s eyes, the reduced manual dexterity resulting from the use of graspers instead of the hands and the reduced availability of surgical tools such as suture devices used in the open approach.

In order to adapt to these novel conditions, the surgeon has to perform many of these laparoscopic procedures, repeating the gestures until he/she is able to perform the procedure safely. Indeed, a recent study compares the open and the laparoscopic approaches for pancreatoduodenectomy in a group of surgeons who had performed at least 20 laparoscopic pancreatoduodenectomies prior to the study. It reveals that more patients died during the first 90 post-operative days in the laparoscopic group than in the open surgery group (Van Hilst et al. 2019). The authors conclude that the surgeons, despite having repeated the new procedure at least 20 times before the study, were not yet “trained” enough to achieve the same results as those using the standard open approach. It is known from other complicated operations that a minimum of 35–40 interventions may be necessary to reduce surgical complications (Tapias and Morse 2014, 1130). In other words, automatisms and repetitive actions, usually regarded as rather dull and non-reflexive, are important with regard to a patient’s well-being and in fact demonstrate an intense and laborious investment by the surgeon. The more experience one obtains, the more repetitive a gesture becomes, and the safer the surgical intervention becomes. In Dewey’s terms, a newly acquired technique has to become a habit of action. Surgical know-how and expertise are thus bound to technical proficiency and skill.

Another frequently observed situation during surgical interventions is the need to adapt the surgical gesture and operation to the individual anatomical variations of the patient. For example, in liver transplantation the main challenge is to restore blood flow to the transplanted liver, referred to as the graft. For this purpose, the transplant surgeon connects the artery of the graft to the artery of the patient receiving the graft. Sometimes, this connection is not feasible for anatomical reasons: the artery is too short, or the wall of the artery is too fragile to perform a suture. This forces the surgeon to adapt and perform an alternative connection by interposing an additional blood vessel, referred to as conduit. The

decision to perform such an alternative connection and how to perform it is often only made during the surgical intervention since it is based on the particular anatomical conditions. Hence, the surgeon must be able to improvise and to use the different surgical techniques at his/her disposal to interpose a conduit (Reese et al. 2018, 552). However, although conduits present a viable option in such an emergency situation, they are not standard procedures and are thus rarely performed. This example shows how surgeons can be confronted with a blockage to their surgical habit of standard procedure and how they have to rapidly decide to reorient their action.

In addition, while the technical gesture of establishing conduits adds another layer of complexity to the surgical intervention, it also has long-term consequences for the patient. Conduits present a higher risk of occlusion or thrombosis compared to the standard arterial connections and may lead to non-functioning of the graft or even the patient's death (Reese et al. 2018). Hence, by choosing to deviate from the standard, the surgeon exposes the patient to a higher risk of thrombosis in order to be able to successfully perform the whole transplantation.

The example of the conduit illustrates that the surgeon is not only forced to adapt to an unforeseeable situation, a blockage to habit, but also has to take a quick decision to overcome this blockage. The decision in turn has to rely on judgment, which is imposed by the imperative of accomplishing the surgery without endangering the patient's life during the operation. In other words, it is the aim of guaranteeing the patient's well-being and in some situations also survival that gives a signification to surgical techniques and more generally the whole enterprise of surgical interventions. Judgement is thus not a mere theoretical endeavour but directly bound to the surgeon's own set of technical skills. Furthermore, at the time of decision-making, the long-term consequences of the intraoperative judgement are not foreseeable with complete certainty and will only reveal themselves after surgery. The surgeon's experience with judgements during previous complicated cases will help him/her to develop the skill of decision-making during future surgical operations.¹²

7. Conclusion

In this article, we illustrate the different technical activities of the surgeon, ranging from the usage of technical tools and machines to participating in the evolution of such tools via invention and the technical adaptation to new objects and the anatomy of the patient during surgical operation. Moreover, given the unpredictability of intraoperative situations, the surgeon needs to rapidly adapt surgical techniques while guaranteeing that the patient's life is not endangered. Such rapid adaptations are based on surgical knowledge; that is, decision-making and judgements, which evaluate present techniques of operations with regard to the aim of assuring the well-being and survival of the patient. From our perspective, the latter might be the main difference between technical activities operated on technical objects and the surgeon's technical activity. While reparation or construction of a technical object also aims at obtaining a functioning object as a whole, the difference remains that in the light of Simondon's ontological human-machine-difference, machines are not alive. The surgeon operates via tools on a living human being and this is the main

¹² On the uncertainty of judgements, Dewey (2008b, 144) writes: "The moral is to develop conscientiousness, ability to judge the significance of what we are doing and to use that judgement in directing what we do, not by means of direct cultivation of something called conscience, or reason, or a faculty of moral knowledge, but by fostering those impulses and habits which experience has shown to make us sensitive, generous, imaginative, impartial in perceiving the tendency of our inchoate dawning activities."

difference between a technician in the orderly sense and the surgeon. However, with regard to the surgeon's inventive and practical skills, as well as the evolution of surgical objects, surgery does not differ much from other realms of technology.

By looking at the surgeon as a technician with manual skills, technical knowledge and inventive creativity, it is possible to highlight aspects of surgery often neglected as a result of the dominance of scientific and evidence-based practices in modern medicine. Revalorizing a technical perspective on surgery may, for example, help us to reflect on the implementation of novel surgical tools and help to reform the training and education of young surgeons.

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