

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

6,900

Open access books available

186,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Risk Assessment in the Anaesthesia Process

Valérie Neyns, Ophélie Carreras,
Laurie Planes and Jean-Marie Cellier
*University of Toulouse le Mirail
France*

1. Introduction

Typically, the patient considers the anaesthesia process as risky (Marty, 2003). Indeed, the anaesthetist has to understand risks related to the patient and also to the surgery. There are many ways to define risks according to the point of view adopted.

In medical setting, risk can be defined using the ISO 12000-1 and the OSHAS 18001 standards. So, risk is defined as a measure of threat expressed in terms of the occurrence of an adverse event (*i.e.* its probability and its frequency) and a measure of its effects or its consequences. In anaesthesia, three criteria are commonly used to describe risk: the event gravity, the occurrence frequency and the level of acceptability. The first one, the event gravity, can be seen as a qualitative scale with 4 major steps: minor risk (*i.e.* error without prejudice for the patient), significant risk (*i.e.* self-limiting prejudice), major risk (*i.e.* error needing a recovery action) and risk evaluated as serious to critical (*i.e.* permanent damage). The second scale, the occurrence frequency, contains 5 major steps: highly unlikely (*i.e.* frequency $\leq 10^{-5}$), very unlikely (*i.e.* $10^{-5} < \text{frequency} \leq 10^{-4}$), unlikely (*i.e.* $10^{-4} < \text{frequency} \leq 10^{-3}$), probable (*i.e.* $10^{-2} < \text{frequency} \leq 10^{-1}$) and very likely to sure (*i.e.* $> 10\%$). The last one, the level of acceptability, is divided into 3 parts: non-critical risks (*i.e.* acceptable risky situations), risks to be monitored (*i.e.* acceptable risky situations but actions are needed to identify and monitor them) and rush through risks (*i.e.* not acceptable risky situations requiring actions to reduce risks or to monitor them).

In France, there is a step entirely devoted to anaesthesia risk assessment: the pre-anaesthesia consultation. But this is a French uniqueness. Indeed, in other countries (*e.g.* Quebec), the anaesthetist will see the patient at the entrance to the operating room. However, the anaesthetist may not assess all risks during the anaesthesia consultation. In this chapter, we will study how does an anaesthetist assess risks linked to a patient who must have a surgical operation before and during this one.

We will present this chapter as follow. First, we will describe the anaesthesia process in France and some epidemiological studies on risks in anaesthesia. Then, we will present some cognitive psychology concepts related to planning, information gathering, resilience engineering and management (*i.e.* error detection, identification and recovery). Two studies will be presented by the method used and results obtained. The first one concerns a card sorting experimentation (with patient records) to understand how anaesthetists gather

patient’s files according to their risk. While the second one consists in semi-structured interviews revolved on simulated cases using the information on request technique. Finally, our results will be discussed in regard of theories used.

2. The anaesthesia situation

In this first section, we will present the anaesthesia situation according to the temporal organisation of the anaesthetist’s activity situation characteristics and constraints. Finally, risks linked to anaesthesia will be presented through epidemiological studies.

2.1 The anaesthesia process

Anaesthesia is commonly defined as the administration of medications, called anaesthetics, to control pain during a medical procedure or surgery. There are three kind of anaesthesia: the local one used for minor surgery; the regional one inducing sedation and, the general anaesthesia used for major surgeries and inducing unconsciousness and complete pain control. In this chapter, we will mainly focus on general anaesthesia.

Moreover, the anaesthetist has 3 additional roles. First, he has to work in collaboration with the surgeon to evaluate and prepare the patient. Second, he has to provide medical care to the patient during the surgery. Finally, he is directly involved in the patient’s management after the surgical intervention (Chung & Lam, 1990). According to these roles, 3 phases are distinguished: the pre-operative one, the per-operative one and the post-operative phase. The figure 1 presents the anaesthesia process in France.

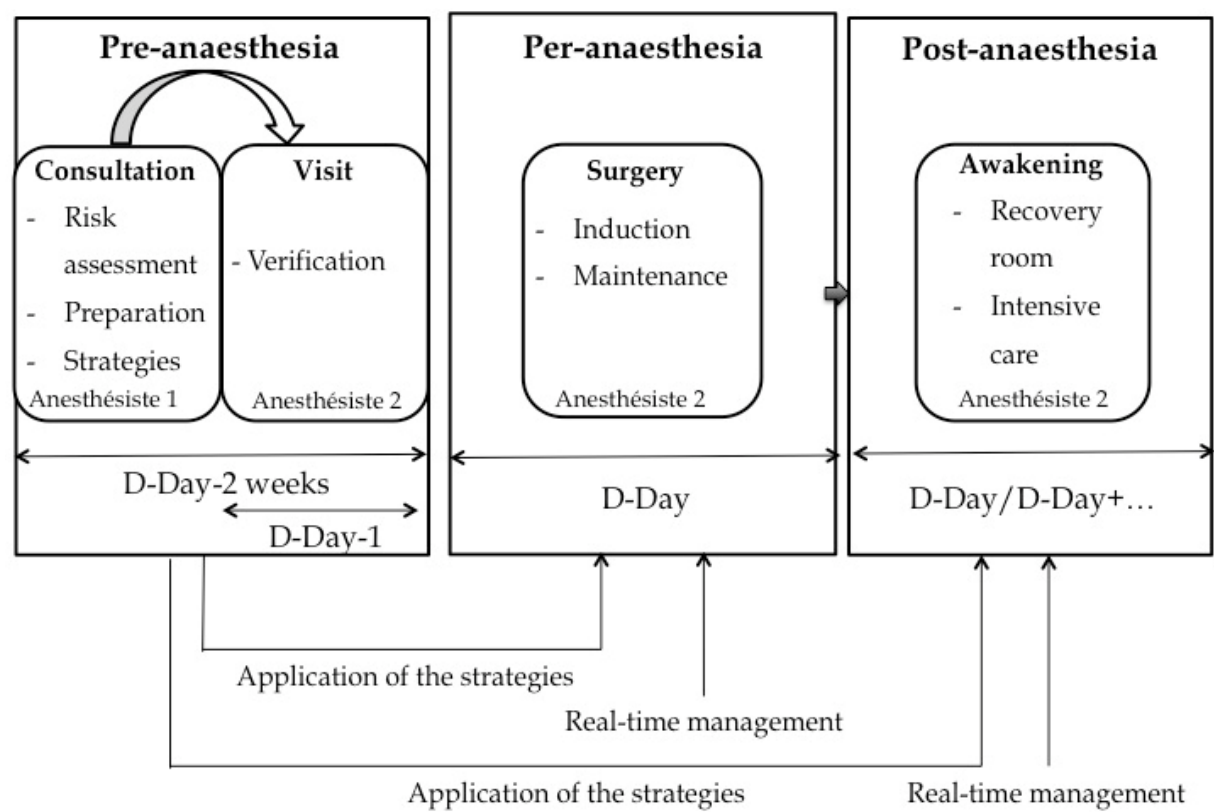


Fig. 1. The anaesthesia process in France

2.1.1 The pre-operative phase

This phase, the first box on the left, allows the anaesthetist to prepare the patient for the surgery and to highlight important elements to consider during this one (Anceaux & Beuscart-Zéphir, 2002). Due to the French specificity (for recall, the existence of a specific consultation). This first phase is divided into two different steps: the consultation and the anaesthetic visit.

The consultation takes place 2 weeks before the surgery. During this one, the anaesthetist looks for information about the patient's disease through interviews (medical history, comorbidities, medication and allergies) and physical examination, establishes a family medical history and tries to reassure the patient. This one allows the anaesthetist to prescribe additional tests, to adapt the treatment, and if needed, to optimize the patient's health.

The second step, the anaesthetic visit, takes place the day before or the same day of the surgery. Its major aim is to verify the absence of interfering elements occurred between the consultation and the visit.

2.1.2 The per-operative phase

This second phase starts when the anaesthetist meets the patient at the entrance to the operating room. Two different steps compose this phase. The first one is the anaesthesia induction. It means the administration of anaesthetic agents and the establishment of adequate depth anaesthesia for surgery. It is an important step physically and mentally (McDonald & Dzwonczyk, 1988; McDonald et al., 1990; Gaba & Lee, 1990). Physically because a lot of actions are needed (Xiao, 1994): preparation and injection of anaesthetic drugs, airway intubation, breathing circuit connections, programming a precise mechanical ventilation, etc. Mental workload is also observed. In fact, the patient's physiological status will change very quickly due to injected drugs. To interpret all the information relayed by the monitoring and the physical examination, the anaesthetist has to construct a specific representation of the patient's health state. Then, he has to check the data progress.

The second step of this phase is the maintenance of anaesthesia throughout the medical procedure. During this step, the anaesthetist's main task is to monitor the patient's vital signs and the progress of surgery.

A task analysis (Neyns, 2011) has highlighted 4 categories of anaesthetists' observable behaviours.

The first category relates to the anaesthetist's need to monitor the situation, assess the evolution of specific variables, understand the situation, etc. It is the **information-gathering step**. Five sources were underlined: *the patient's record* that includes both the pre-anaesthetic file (from the consultation and additional assessments) and the per-operative sheet that includes all patient data (drugs injected, vital signs, all relevant information); the *monitoring and its alarms*; the *surgery status and progress* allowing to explain changes in patient's vital signs or to restore the patient's anaesthesia; information taking on *patient* (apart from monitoring data) used to confirm hypothesis; and information related to *hour* either to check the schedule or to check the drugs effect, or for a personal need.

The second category refers to variables that are not directly controlled by the anaesthetist (*e.g.* the conduct of the intervention). He has then to refer to other members in the operating room (*e.g.* surgeon, nurses, surgical assistant, etc.) and to other health care professionals who are not directly involved in the surgical procedure (*e.g.* cardiologist, critical care services, recovery room, etc.). It is **functional communications** between the different members. These communications can go from the anaesthetist to other members but also to the anaesthetist. The communication objects can be multiple: to provide/exchange information, to help the anaesthetist to detect/identify a problem, to discuss plans for the previous/present/next patient, etc.

The third category includes the anaesthetist's **actions on the environment** (*e.g.* actions on the monitoring interfaces to facilitate data interpretation or to set to the patient's vital constants, preparation of the equipment, etc.) and **the patient** (*e.g.* drugs injections, intubation, etc.). His actions are initiated by either obligatory procedure (*e.g.* prescribed tasks), or action plans, or by environment data (*e.g.* information gathering/communication/alarms). Concerning alarms, they play a role in detecting problems. Some alarms can be the result of a failure in the patient's vital signs. The anaesthetist will act to restore the situation in a "normal way". But others can be caused by interferences (*e.g.* the electric scalpel of the surgeon can cause false cardiac dysrhythmia). These alarms are ignored because they are not significant and the anaesthetist cannot do anything against them. Finally, other alarms prompt the anaesthetist to seek for further information (*e.g.* check the surgeon's advice about the surgery, an act painful for the patient can lead to an increased heart rate).

Finally, the fourth category includes two types of actions: **non-functional actions** that are not related to the intervention (*e.g.* reading articles or emails and communications with other members, telephone, etc.) and the **anaesthetist's absence** from the operating room who delegates the process supervising to other members in the operating room.

Thus, this task analysis shows that the anaesthesia management includes extensive information and various parameters can be taken into account. It demonstrates the system complexity and its relative reliability.

2.1.3 The post-operative phase

This last phase mainly concerns the patient's awakening. Once the surgery is completed, the anaesthetist has to reverse the effect of anaesthesia as quickly as possible.

Another characteristic of the anaesthetic process in France is that the anaesthetist involved in the anaesthesia consultation will not be necessarily the one on call during the surgery. This cooperative activity implies that the anaesthetist in charge of the consultation collects relevant information about the patient, builds a representation of this case, plans activities and finally chooses the information to convey to his colleague. This information will be provided on an anaesthetic file which is used as an external memory (Anceaux et al., 2002 ; Thuilliez et al., 2005; Neyns et al., 2010).

In summary, anaesthesia process is a dynamic and complex work environment sharing common characteristics with other dynamics work environments as aviation, car driving and nuclear power plants management (Woods, 1988; Vicente, 1999).

Such situations are highly risky due to their dynamics characteristics. In the next section, we will present epidemiological studies on anaesthetic security.

2.2 Risks in anaesthesia

As reported by the French Society of Anaesthesiology (SFAR, 2010), the rate of serious complications in the world is still 14 millions with a death rate of 2 millions. While some studies (Marty, 2003; Amalberti et al., 2005) have shown that anaesthesia was a safe system even so there are more difficult patients (older, more complicated diseases, etc.) and more complex surgeries, etc. Epidemiological studies have enabled to highlight risky factors in anaesthesia (*e.g.* Cohen et al., 1988 ; Sfez, 2002).

Classically, two kinds of risks are distinguished: risks in the operating room and out of this one. Two predominant factors were highlighted by epidemiological studies (*e.g.* Cohen et al., 1988; Arbous et al., 2001). The first one is the most important in the operatory mortality and concerns the patient's features (physical state, age, gender). The second one is related to the surgery difficulty depending on the level of complexity (minor, intermediate, major) and the status of surgery (planned or urgent). A third one is also observed: the risk linked to the anaesthesia. Three kinds of variables in risks strictly linked to anaesthesia are identified: (1) the inadequate assessment and preparation of the patient to the surgery (25%); (2) the unsuitable choice of an anaesthetic technique (15%); (3) a wrong recovery action (56%). But this last risk is not really salient. More precisely, Lagasse (2002) estimates that the risk strictly linked to the anaesthesia is less than 1/10000, while the risk linked to the surgery is 1/100 to 1/1000 and the one linked to the patient is correlated to the patient's ASA score¹ (*e.g.* ASA3 = 1/10000, ASA4 = 5/10000 and ASA5 =14/10000).

In summary, these results justify the relevance of anaesthetic consultation for the risk assessment and the patient's preparation to the surgery. However, this one is largely responsible of some complications (coupled with an inadequate choice of technique included in the anaesthetic evaluation). The study led by Zhang et al. (2002) has pointed out that the solution to many medical errors was to understand the operator's cognition and to adopt cognitive methodologies to prevent and avoid these errors. In the next section, we will present studies in cognitive psychology to highlight the cognitive mechanics involved in anaesthesia risks assessment (*e.g.* anticipation) and risks management (*e.g.* error detection and recovery).

3. Some psychological concepts about risk management in dynamic situation

In the management of a dynamic situation such as anaesthesia, the time management is important (*e.g.* Carreras et al., 2001). In fact, a dynamic environment can be managed before,

¹ ASA is a physical status classification system for assessing the fitness of patients before surgery. It is a six-category classification system. ASA1 for a normal healthy patient; ASA2 for a patient with mild systemic disease; ASA3 for a patient with severe systemic disease; ASA4 for a patient with severe systemic disease that is a constant threat to life; ASA5 for a moribund patient who is not expected to survive without the surgery and ASA 6 for a declared brain-dead patient whose organs are being removed for donor purposes.

during and even after the process in itself (Morel et al., 2008a, 2008b). The operator has to learn to anticipate his actions and especially their effects. However, the different interactions between multiple variables do not always allow anticipating all the effects of operator's actions and the system evolution. So the operator must deal with uncertain situations in real time and adapt to variables involved in the process and their interactions. This adaptation refers to resilience that is defined as the ability of systems to find a stable state after a major disturbance and/or in a stressful situation (Hollnagel et al., 2006). According to Cook and Woods (1994), the first source of resilience is the human operator. Indeed Reason (2008) describes the human operator as *"an hero, a system element whose adaptations and compensations have brought troubled systems back from the brink of disaster on a significant number of occasions"* (p.3). In this chapter we will mainly discuss the risk management before and during the process.

3.1 Risks management before the process

As said earlier, the human operator can perform his task on a reactive mode but also on a proactive one. This last one permits to view the situation in the near future (limited by operator's knowledge and the rapid evolution of the process and its uncertainty) and makes possible the selection of information (filtering) (Hoc, 1995). We can observe such mode before the process with anticipatory activity (plans) but also during this one with the implementation of plans built, the preparation of the next action or a sequence of actions (Hoc, 2006). According to Cellier et al. (1996), anticipation in a dynamic work environment consists in (1) evaluating the future state of a dynamic process, (2) determining the type of actions to undertake and the moment when it must be done, and (3) mentally evaluating the impact of those actions. Denecker (1999) describes the anticipation on two different modes. The first one is considered as an explicit prediction or forecasting. The second one is implicit and expressed in a selective preparation to situations or an expectation of events. In this chapter, we will mainly focus on the explicit mode.

Regarding the anaesthesia situation, several studies (Xiao et al., 1997; Neyns et al., 2010) have shown that some strategies were built in advance during the pre-anaesthesia phase. Xiao et al. (1997) revealed that anaesthetists identified during this phase a list of "points for consideration". This list includes the specific conditions in the patient's physiology, anticipated events, and risks. This one functions then as a set of "warning" that guides the anaesthetist's attention in a dynamic, multi-tasking situation. However, Neyns (et al., 2010) showed that this list reflected a wide anticipation range (Boudes & Cellier, 1998). It means that this list does not contain planning elements per se, but they can guide attention in the anaesthesia activity where timing constraints are important. Thus the information recorded by anaesthetists concerns the plans adjustment and little information concerns the development or the selection of a plan (Anceaux, et al., 2002). The information contained in the consultation files has two distinct purposes: (1) to assess the risk factors and to prevent them by the development of strategies (related to the patient and the surgery), and (2) the identification of specific problems (Neyns et al., 2010).

Finally, other studies (Anceaux et al., 2002; Anceaux et al., 2001; Beuscart-Zéphir et al., 2001; Thuilliez, et al., 2005) have pointed out that the way to anticipate during the first phase depended on the anaesthetist's expertise and the case complexity.

However the limits of projection into the future described above (the knowledge, the rapid evolution and the level of uncertainty) also require a reactive mode. This reactive mode corresponds to the resilience (Hollnagel et al., 2006)

3.2 Risks management during the process

All the risks cannot be anticipated. As we have seen before, certain risks are taken into account and actions are proposed (prediction, strategies of avoidance or management) and implemented, while others are ignored or not perceived, and their management is postponed (if they appear) in the process management. This type of management suggests a certain “allostasis risk” (Fuller et al., 2008). This second section aims to understand how operators manage risks postponed in the process management.

Although it is widely accepted that the operator commits many errors (Reason, 1990), he also detects the majority of them (at least 60% according to Allwood, 1984; Rizzo et al., 1987). Error detection is the first step in the risk management during the process. During this step, there is still no explanation of the error (Zapf & Reason, 1994). The operator is aware of the existence of a gap between what he obtained and what he expected.

Error detection can be done automatically, spontaneously and unconsciously or it is the result of a more aware comparative treatment with the initial objective (in terms of results, performance) or when the operator can no longer act on the system (Allwood & Montgomery, 1982; Allwood, 1984; Sellen, 1990; Sellen & Norman, 1992; Sellen, 1994; Rizzo et al., 1995;). Finally, the intervention of a third person is also a key factor in errors detection (Woods, 1984; Nyssen, 1997).

Sellen (1990, 1994; et al., 1992) suggests that operator, before recovering the error, would be able to identify it. This identification process consists in a comparison between results obtained and those expected. Nevertheless, it is also possible that the operator detects an error without necessarily identify it or to identify it without necessarily recover it. Indeed, a significant part of detected but also not detected errors does not have any consequences (or little) on the process. Error recovery is often considered as the last step in risk management. It allows the operator to remove or reduce the gap between what he gets and what he wanted to get. Once the error is detected, recovery actions can take many forms (Sellen, 1990). But the recovery process will not be detailed in this chapter.

Regarding the anaesthesia situation, little attention has been paid to the mechanisms of error detection. Indeed the majority of research focuses on the study of the errors prevention (e.g. Cooper, et al., 1984; De Keyser & Nyssen, 1993; Cooper, et al., 1982; Finley & Cohen, 1991). In 2006, Nyssen & Blavier have shown that the majority of incidents were detected during the regular monitoring of parameters and on the basis of external signs, suggesting an “automatic” mode. The expertise seems also to play a role in error detection (Nyssen & De Keyser, 1998). The most experienced ones diagnose the problem with significantly less time than novices.

Finally, most studies about risk management (see Cooper et al., 1984) showed that anaesthetists do not taken seriously into account infrequent risks. Risk management depends thus mainly on the anaesthetist’s ability to respond quickly and appropriately when a problem occurs.

In summary, various studies have focused on highlighting either prevention strategies in advance or management strategies in real time. But none of them has yet made the connection between what is evaluated during the consultation and in the operating room. The French anaesthesia situation permits to study this assessment at both phases. More specifically, we want to answer the following questions: (1) what kind of risk is used when an anaesthetist has to assess a patient's file? Some studies have emphasized the effect of certain variables on the process of risk assessment. For example, Anceaux et al. (2002) showed that the case complexity could influence how to proceed with the patient during the consultation. Epidemiological studies (e.g. Lagasse, 2002) have also identified three kinds of risks as the cause of problems: those related to the patient, surgery and anaesthesia itself. It would be interesting to know how anaesthetists assess risks involved according to their complexity. (2) Epidemiological studies have shown on the one hand that infrequent risks are not taken into account by an anaesthetist (e.g. Cooper et al., 1982) and on the other hand that there are often problems when the anaesthetist can assess and prepare a patient (e.g. Arbous et al., 2001). How important are the risk frequency and the risk predictability in the assessment and the management in real time?

The next two studies tend to answer these questions and to understand the link between consultation and the anaesthesia in itself.

4. Study one: What kind of criteria does anaesthetist use to assess risks linked to a patient based on consultation information?

This first study aimed to understand how anaesthetists gather patient's files according to their risks. We supposed that information gathering and plans production would depend on operators' level of experience and risks level, without indication about the kind of risks used (patient, surgery or anaesthetic). First, we will present the method used to answer our question and the method used to treat our data. Finally, we will present results obtained. A brief discussion will be proposed to introduce the next study.

4.1 Method

We proposed a card-sorting task using patient's records. All the patient's files were constructed using real patients with the help of an experimented anaesthetist. Four kinds of patient's files were constructed according to the level of complexity defined by 2 combined variables: the surgery complexity (easy and complex surgery) and the complexity related to the patient's health (healthy and unhealthy patient).

An easy surgery is defined as a short-term surgery, minimally invasive (e.g. surgery for a breast cancer). A difficult surgery is defined as a long duration surgery (6 to 12hours) that is invasive or mutilating (e.g. surgery of the larynx cancer). A healthy patient is described as a normal healthy patient (e.g. ASA1) or with mild systemic disease (e.g. ASA2). The patient with a complex health status is a patient with important comorbidities and taking many drugs (e.g. ASA3 or 4).

Combining these 2 variables, 4 kinds of cases were obtained: easy surgery with healthy patient (called OSPS); easy surgery with unhealthy patient (called OSPC); complex surgery with healthy patient (called OCPS) and, complex surgery with unhealthy patient (called OCPC).

Each patient's file contained the following information in the same order: surgery information (name, operating position, surgery duration, type of intervention, risk of infection, latex allergy); patient's information (gender, age, weight/height, medications, comorbidities, other allergies, dentures, medical and surgical histories); data from the clinical examination (cardiovascular, pulmonary, intubation, risk of post-operative nausea and vomiting, remarks); conclusion made according to information from consultation (ASA score).

Sixteen patient's records (4 records by kind of cases) were constructed and presented in a random order. Anaesthetists were asked to sort them into several distinct groups such as they "go well together" using the think aloud method. At the end of the task, they had to explain their choices of categories giving them a title.

Twenty anaesthetists volunteers participated: 10 experienced anaesthetists (average years of experience=21.2, SD=6.23) and 10 novices (average years of experience=4.2, SD=0.4). They all came from different departments and different medical structures. They were recruited by mail or by phone. The entire experience lasted up to 30 minutes.

Data will be first analysed according to the produced categories: number of categories and titles given to each category. Then, information used to produce categories will be recorded and compared according to the level of experience. Finally, verbalizations will be analysed as a material language and exploited through an approach of natural language processing (NLP). This use of NLP is in line with works on texts profiling (see Planes, 2011). We wanted to highlight experts' and novices' profiles answering the following question: What kind of information the two groups use when they assess a patient's file? Lexico, a language tool for analysing corpus, will be used (see Lebart & Salem, 1994). This tool allows to manipulate some statistical calculation on corpus (more particularly frequencies) and to calculate specificities (in other words, "are some terms more specific to experimented anaesthetists than novices?").

4.2 Results

In this second subsection, we will firstly present categories produced by the two groups of anaesthetists according to their number and their titles. Finally, information used from their verbalisation data will be explained with the Natural Language Processing (NLP).

4.2.1 Produced categories

Anaesthetists construct different categories according to their level of experience. The more experienced anaesthetists build more categories ($M=4.4$, $SD=0.52$) than novices ($M=3.5$, $SD=0.53$). The t-test applied to the data confirms that the level of experience influences the differentiation between patient's records ($t(18)=3.86$, $p<0.001$, $d=1.8$).

Regarding the titles of categories, a difference is observed according to the level of experience. The table 1 and 2 show labels given to the categories formed by the two groups, the participants' number giving this label and the average number of reports in each category formed.

Looking to the first table, categories made by experimented anaesthetists, it seems that they mainly use the surgery difficulty and the risk level associated to patient's health. Some other

categories can highlight specific problems (*e.g.* neurological problems, attention to the induction time).

Categories Label	Participants' number	Average number of reports
Easy surgery, healthy patient	10	5.8
Easy surgery but patient with mild systemic disease	8	3.4
Surgery moderately complex with minor risks	8	2.1
Complex surgery with major risks	10	4.4
Neurological problems	1	4
Very difficult case	2	2.5
Attention to the induction time	2	2.5

Table 1. Categories made by experimented anaesthetists

Categories Label	Participants' number	Average number of reports
Not at risk	8	5.5
Low level of risk	6	4.5
Long surgery, low-risk patient	2	3
Very high risk	10	4.7
Intermediate risks	4	4.25
Additional tests	1	2
Post-operative management	1	1
Particular intubation	1	3

Table 2. Categories made by novices

Regarding the second table, categories made by novices, it seems that they manly used the overall risks and do not really distinguish what is related to the surgery and to the patient. There is just one category that includes this differentiation, the category named “long surgery and low-risk patient”, but it is poorly used (just 2 novices with an average of 3 reports). Finally, they also use some categories highlighting specific problems (*e.g.* additional tests, post-operative management, particular intubation).

In summary, 90% of experimented anaesthetists distinguish the difficulty of the surgery and risks linked to the patient’s health state, while 60% of novices suggest the overall risk associated with patient’s files. According to the number of categories formed and qualitative analysis of labels, experimented anaesthetists use more differentiations between records than do novices. In the next subsection, we will present how anaesthetists analyse a patient’s file through the natural language processing.

4.2.2 Information used by the two groups

This subsection concerns the information use to assess patient’s files.

The table 3 shows the average number of information used according to the cases and the anaesthetists’ level of experience. Even if there is an augmentation of the information used according to the level of complexity ($F(3,54)=66.09, p<0.0001, f=1.92$), there is no effect of the level of experience on the number of information used ($F(1,18)=1.09, NS, f=0.25$).

	N	OSPS		OSPC		OCPS		OCPC		Average
		M	SD	M	SD	M	SD	M	SD	
Experimented	10	19.8	3.08	30.3	2.94	31	3.22	37.3	4.95	27.1
Novices	10	24.9	4.68	36.4	5.03	26.7	4.24	33.5	3.82	30.38

Table 3. Average number of information used according to the level of complexity and the anaesthetists' level of experience

According to the NLP, the figure 2 shows frequencies of criteria used by the two groups (experimented and novices) in their verbalization data. Results show that experimented anaesthetists use 4 different criteria. They use more frequently the patient criteria (frequency=406), followed by the surgery criteria (frequency=217), the risk criteria (frequency=138) and finally, the problem criteria (frequency=118). Novices use also 4 different criteria. They use more frequently the surgery criteria (frequency=373), directly followed by the patient criteria (frequency=321) and less often the risk (frequency=100) and the problems criteria (frequency=57).

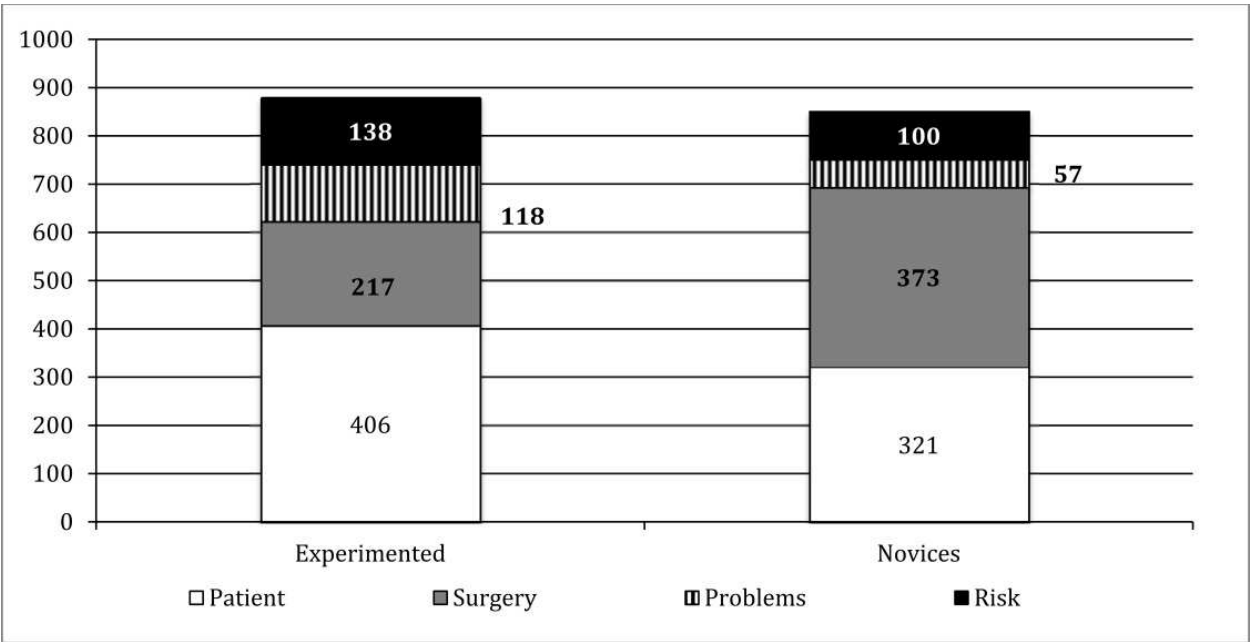


Fig. 2. Frequencies of criteria used to assess patient's files according to the level of experience (verbalization data)

As showed on the figure 1, two major differences appear between the two groups. Experimented anaesthetists mainly use the patient criteria when they have to assess a case,

while novices use the surgery and the patient criteria without significant distinction. Finally, experimented anaesthetists and novices assess not only risks but they also highlight some specific problems to consider, even if the experimented ones use it more often. This last difference has a particular interest for us: either novices do not look at these particular problem as much as experts, or they use other words to describe these elements due to a difference in the vocabulary used.

The figure 3, called problems frequencies underlined by experimented anaesthetists and novices, shows that the two groups highlight all the problems. But the experimented ones underline problems more often than do novices (4 kinds of problems are more often cited by experimented anaesthetists while novices identified only two kinds most frequently).

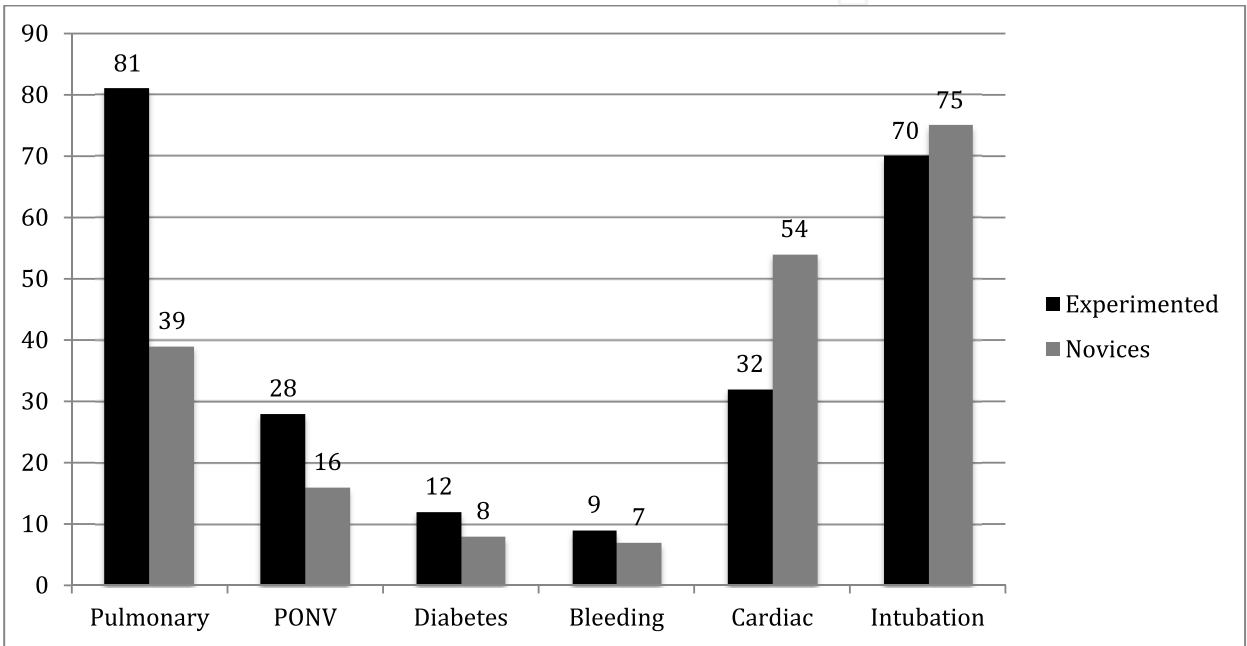


Fig. 3. Problems frequencies underlined by experimented anaesthetists and novices

In summary, it appears that novices look the same information in the records than experimented anaesthetists. However, novices consider them less frequently as problems and analyse it as a whole. This suggests the existence of different strategies among experience level. With experience, anaesthetists can focus only on the potentially problematic aspects of patient’s files.

4.3 Brief discussion of the first study

This first study permits to put in light differences in the risk assessment. In fact, the level of experience seems to be a relevant factor in it. As developed through epidemiological studies, our results insist on difficulties linked to the patient’s health state and the surgery. Anaesthetists, whatever their level of experience, use these two criteria more frequently. However, the more experimented anaesthetists seem to insist on patient’s risks factors than novices. These last ones seem to use both of these criteria to assess risk linked to one case. Finally, risk assessment is also a way to put some warning flags on points for consideration. That confirms Xiao’s results (1996).

5. Study two: How does an anaesthetist assess risks during a surgical intervention?

The first study was only focused on the risk assessment that can occur during the consultation. This second study aims to investigate it during all the anaesthesia process. We wanted to see how anaesthetists assess a predictable risk and how they do when they face an unpredictable risk. We supposed that anaesthetists would pay more attention to a predictable risk than to an unpredictable one. This attention would be clearly observed in the risk assessment during the consultation and also, in the risk management (during the surgery) by a better detection/identification. First, we will present the method chosen to answer our question and finally, we will present and discuss briefly a part of our results.

5.1 Method

This second study consists of semi-structured interviews revolved on simulated cases (already validated in Sfez, et al., 2008) using the technique of information on request (see Rimoldi, 1963). These cases were presented on vignettes that described an anaesthetic situation that deviated from its normal course.

Cases were selected based on two criteria: the frequency of occurrence and the predictability. Four cases were used in the experiment: the case of difficult intubation (predictable or not) and the case of malignant hyperthermia (predictable or not). The first case, difficult intubation, is a common situation. Moreover anaesthetists have to evaluate the intubation criteria during the consultation through patient's body inspection (mouth opening, length of upper incisors, relation of maxillary and mandibular incisors during normal jaw closure and during voluntary protrusion of mandible, intercorisor distance, visibility of uvula, shape of palate, compliance of mandibular space, thyromental distance, length and thickness of neck, and range of motion of head and neck) and patient's interview (familial history). They also have a difficult airway algorithm (developed by the French Society of Anaesthesia) allowing them to choose an adequate technique according to the patient's criteria. In this simulation, the case of difficult intubation was coupled with gastric oesophageal reflux, which occurs if the anaesthetist does not practice preventive manoeuvre.

The second case, malignant hyperthermia, was chosen because it is a rare life threatening condition in anaesthesia but it can be detected during the consultation. It is usually triggered by exposure to certain drugs used for general anaesthesia. There are also algorithms that manage this risk (strategies for prevention, avoidance and recovery actions). In the case presented, the anaesthetist can either detect the problem during the consultation, either during the anaesthetic induction with warning signs as muscle stiffness, difficulty of intubation due to spasms, breathing problems, increasing of the patient's body temperature and arrhythmias.

Each vignette was divided into 3 phases. The first one was related to the preoperative phase during which the anaesthetist has to be aware of the patient's physical conditions before to put him to sleep and has to determine an action plan to intervene. This phase corresponded to the anaesthesia consultation and to the risk that a problem could appear.

After a brief description of the case including age, weight, height, the surgery planned and the position required, four questions were asked to the anaesthetist. (1) What information do you need to assess risks linked to this patient? (2) On a scale of 0 to 10 (where 0 means “very easy” and 10 “very difficult”) can you estimate the difficulty level for this case? (3) What are the difficulties envisaged? (4) Do you recommend some specific actions for this patient? (Additional strategies: surveillance, specific preparation, etc.). In summary, the anaesthetist was asked to assess risk level associated to this patient and to highlight problems expected.

The second phase was related to the anaesthesia induction. During this phase, the problem really appeared. After reading the description of the situation, three questions were asked to the anaesthetist. (1) Do you need additional information? (2) Are you concerned about some elements of the current patient’s state and the surgery? Could you explain the reason? (3) Are there specific actions to implement? In summary, the anaesthetist had to provide details about his situation awareness, to formulate hypotheses and to suggest recovery actions.

The last phase concerned the anaesthesia maintenance. This one is related to the recovery situation. During this third phase, if the anaesthetist did not make anything, the situation will not be anymore recoverable. After reading the vignette, four questions were asked to the anaesthetist. (1) Do you need more information? (2) Do you need to do something in this situation? (3) On a scale of 0 to 10 (where 0 means “very easy” and 10 means “very difficult”) can you estimate the level of difficulty of the case you just faced? (4) Do you think you could change the course of this event? If so, could you explain how?

The figure 4 presents an example of vignette about an infrequent but predictable problem, the malignant hyperthermia case.

All the interviews were recorded. Each anaesthetist was faced with a vignette presented in a random order. Thirty-four French anaesthetists participated to our study (average years of experience = 17.12, SD = 11.02). They all came from different departments and different medical structures. They were recruited by mail or by phone. The duration of the entire experience lasted up to 10 minutes or 15 minutes.

Data will be analysed as follow. First we will present the anaesthetists risk assessment (the estimation scale of 0 to 10 at the beginning and at the end of the simulation) of the patient according to the two variables: predictability and frequency. There will be also a qualitative treatment of this assessment to demonstrate if the anaesthetist had taken into account or not difficulties presented in the vignette (*e.g.* in the case of difficult intubation, if the anaesthetist diagnosed it in the first stage, he has adequately understood the problem. It is noted 1. Conversely, if the real risk is not taken into account, it is noted 0). Finally, the risk management will be apprehended by 2 kinds of variables: the quality of the detection, identification and recovery actions proposed by anaesthetists and, the number of hypotheses generated. It tends to answer the following questions: “Does the anaesthetist identify correctly the problem?” and “Does the anaesthetist use the correct recovery actions according to specific algorithms?”. It means that if the proposed diagnosis and recovery actions are correct, they are rated 1. In the opposite, if they are false, they are rated 0.

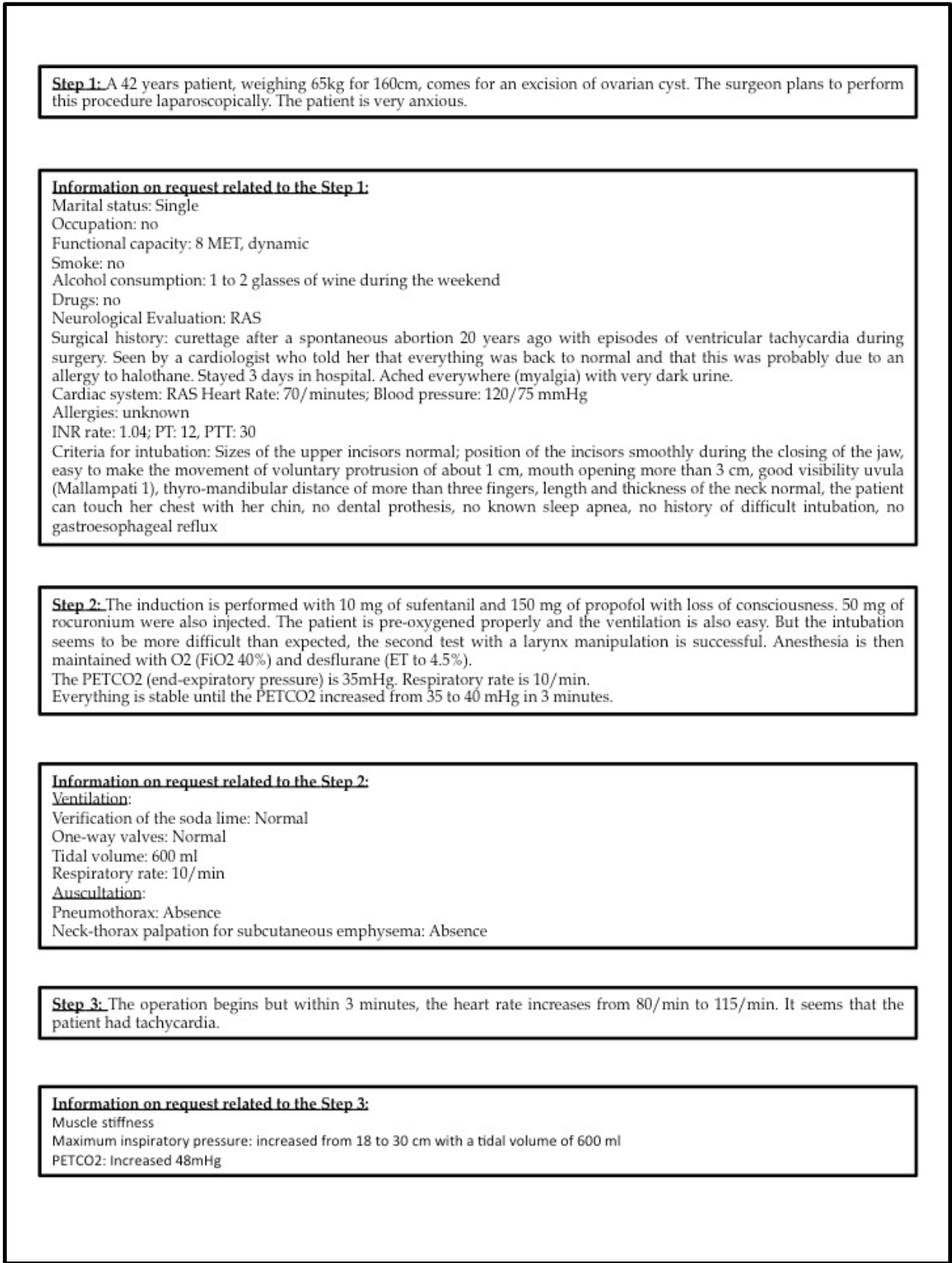


Fig. 4. The infrequent but predictable problem: the malignant hyperthermia vignette

5.2 Results

We will present in this chapter only the results concerning risk assessment before and during the anaesthesia.

5.2.1 Risk assessment during the patient's consultation

The table 4 shows the average level of difficulty estimated by the anaesthetists according to the frequency and the predictability. As expected, a predictable event is always considered as more risky (M=4.06, SD=1.52) than if it was not predictable (M=2.18, SD=1.19). In fact, the t-test shows that this difference is extremely statistically significant ($t(32)=4.02, p<0.0005, d=0.468$). In general, the same is observed for the frequency: a common risk is assessed as more difficult (M=3.35, SD=1.9) than an infrequent one (M=2.88, SD=1.36). But by conventional criteria, this difference is not statistically significant according to the t-test ($t(32)=0.83, NS, d=0.57$).

	Frequent	Infrequent	General mean (SD)
Predictable	4.88 (SD=1.25)	3.33 (SD=1.41)	4.06 (SD=1.52)
Unpredictable	2 (SD=1.22)	2.38 (SD=1.19)	2.18 (SD=1.19)
General Mean (SD)	3.35 (SD=1.9)	2.88 (SD=1.36)	

Table 4. Average level of difficulty according to the frequency and the predictability

Specifically, two major differences appear. Predictable risks are considered as more difficult when they are frequent (M=4.88, SD=1.25) than when they are infrequent (M=3.33, SD=1.41). This difference is statically significant by the t-test applied ($t(15)=2.38, p<0.05, d=0.65$). The same is observed concerning the frequent risk. They are considered as more difficult when they are predictable (M=4.88, SD=1.25) than the reverse (M=2, SD=1.22). By conventional criteria, this difference is considered to be extremely statistically significant ($t(15)=4.8, p<0.0005, d=0.6$).

Regarding the quality of their risk assessments, only 35.3 % of the anaesthetists correctly assess the risk they face and mainly when the risk is frequent and predictable (7 anaesthetists have a correct assessment against 1 who is wrong). Typically, risks identified are mostly distorted by other problems than those presented in vignettes.

5.2.2 Risk assessment during the surgery

Although risks are not correctly identified at the consultation, when problem arises, the majority of the anaesthetists (97%) identified that there was a problem but only 79.4% of the anaesthetists identified correctly the problem they faced.

In general, all the risks are correctly identified. As shown on the figure 5, frequent risks are always identified correctly (100%). Anaesthetists frequently recognized predictable and unpredictable risks (respectively, 83,33% and 75%). The most difficult risk to identify is the one that is infrequent (58,33%) and mainly when it could not be foreseen during the consultation (25%).

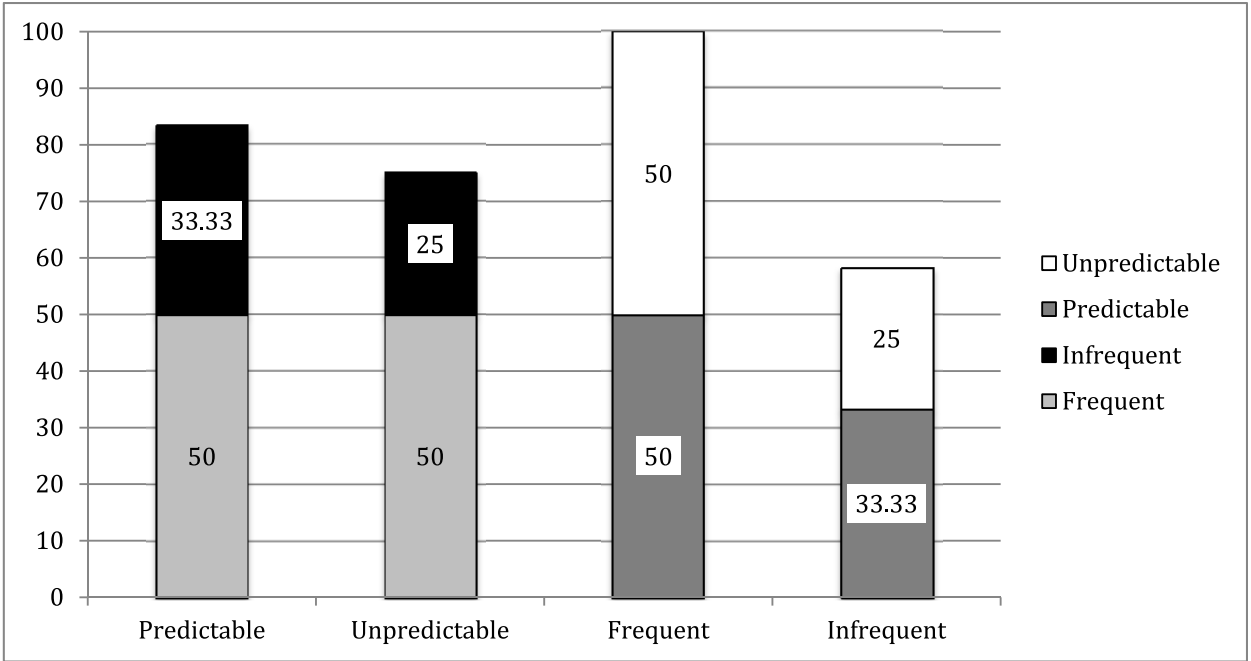


Fig. 5. Percentage of risks correctly identified according to their predictability and their frequency

In average, anaesthetists have advanced 2.24 hypotheses before giving the correct diagnosis (SD=1.16). As shown in the table 5, whatever the frequency or the predictability, there is no difference in the number of hypotheses.

	Frequent	Infrequent	Mean (SD)
Predictable	2 (SD=0.93)	2.89 (SD=1.36)	2.47 (SD=1.23)
Unpredictable	1.89 (SD=0.93)	2.13 (SD=1.25)	2 (SD=1.06)
Mean (SD)	1.94 (SD=0.9)	2.53 (SD=1.33)	

Table 5. Means of hypotheses generated according to the predictability and the frequency (SD)

Concerning the recovery, three results are interesting to quote. First, 3 anaesthetists did not attempt to recover the problem. Second, even if 97% of the anaesthetists identified the risks, only 67.6% of them were able to recover the problem presented. As shown on the figure 6, anaesthetists recovered correctly 94,44% of frequent risks and more often when the risk was predictable (50%). Finally, the less managed risk is the infrequent one (40,97% of anaesthetists were able to provide adequate recovery actions) regardless of its predictability (22,22%) or not (18,75%).

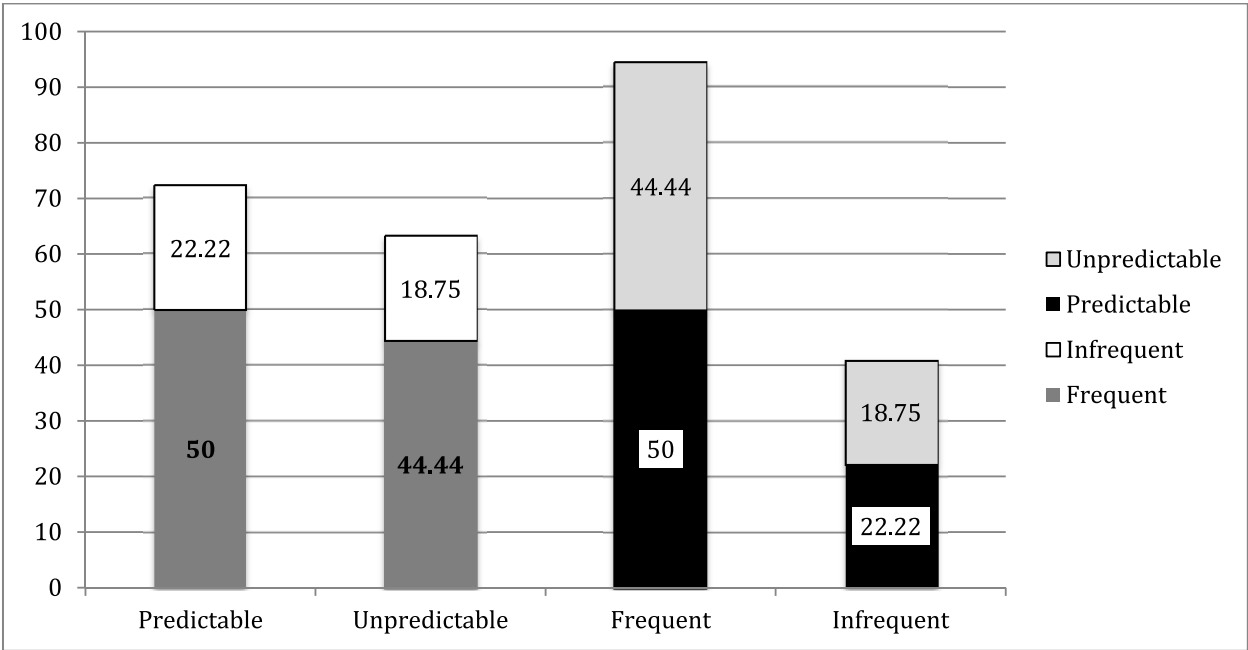


Fig. 6. Percentage of correct recovery actions according to the predicatbility and the frequency

5.3 Brief discussion of the second study

In this second study, we wanted to see how anaesthetists assessed risks before and during the surgery. We were interested by two kinds of variables: the predictability and the occurrence frequency. Our results showed that anaesthetists assessed problems as more risky when they can anticipate it than when they are unforeseeable. However, few anaesthetists were able to correctly assess the risks during the consultation. In fact, their representation were often distorted by others problems. It means that they put a lot of warning flags for each case. One variable seem relevant in the risk assessment and management: the frequency. A frequent risk is always correctly identified and recovered.

In the following section, all the results will be explained regarding the theories used.

6. General discussion

The main objective pursued in this article was to emphasize the risk assessment during the consultation (phase 1 of the process) and during the anaesthesia (phase 2). More specifically, 2 questions have structured our work: (1) what kind of risk is used when anaesthetist has to assess a patient’s file? (2) How important are the risk frequency and the risk predictability in the assessment and the management in real time?

The first research permits us to answer the first question and to study the effect of the experience level on the risk assessment. Our analyses show that the most experimented anaesthetists differentiate more patients’ files regarding to the number of categories formed, the labels given and their verbalizations. Concerning the kinds of risks used, the experimented anaesthetists use most often the complexity linked to the patient to assess a file whereas novices use a more general level of risk without distinction between patient,

surgery and anaesthesia risk, even if their verbalizations show that they use the patient and the surgery criteria with almost the same frequency. Both of them use more information according to the files complexity. Finally, the two groups of anaesthetists use some warning flags to underline some specific problems.

Through this study, our results show that the more experimented anaesthetists build more functional representations because they analyse the situation more broadly. This confirms the results of Cellier et al. (1997) and Hoc (1989). In other words, experimented anaesthetists consider two levels of risk (the patient and the surgery) even if they use more often the criteria related to the patient. That should enable them to anticipate potential incidents associated with the patient and the surgery.

Our results also confirm that two variables can influence the consultation (Anceaux et al., 2001, 2002, 2005): the level of experience and the case complexity. Finally, regarding information used by anaesthetists (all experience level combined) to assess a file, they all point out specific problems. This last point confirms Xiao's results (et al., 1997).

All these elements show that the risk assessment during the consultation leads to a schematic representation that can be then specified later during the surgery (Hoc, 1987).

The second research permits to answer the second question (How important are the risk frequency and the risk predictability in the assessment and the management in real time?). Our results indicate that the risk predictability increases the perceived difficulty level associated with it. Moreover this perceived difficulty is higher when the risk is both frequent and predictable. The risk frequency seems to be important for the identification during the surgery and also for the recovery actions.

Overall, few anaesthetists assess the problem correctly at the end of the consultation (for recall: only 35.9% of anaesthetists assess the real risk). Anaesthetists correctly assess only frequent and predictable risks at this early stage. Concerning the other risks, the anaesthetist's representation is distorted by other problems. Even if the risk is not really perceived during the consultation, the identification is almost correct for all the anaesthetists. We also find that anaesthetists identified and recovered less correctly the infrequent risks.

Finally our results point out that anaesthetists suggest that anaesthetists propose several hypotheses before reaching the right result whatever the nature of the risk according to its frequency and its predictability.

These results confirm epidemiological and psychological studies previously cited. In fact, several explanations can be given to our results. Firstly, previsibility permits to assess (consultation) and to identify (surgery) correctly the risks. Secondly, as Cooper's results (et al., 1982) showed, anaesthetists not taken into account infrequent risks. These ones are not correctly assessed, identified and recovered because there is a misunderstanding. Indeed the majority of anaesthetists faced with a infrequent risk explained that they have been rarely confronted with this kind of risk and most often through simulations. Thus, when the patient presented signs of this problem, they tended to minimize the facts (Amalberti, et al., 2005). Moreover, their representation seems distorted by highlighting other problems (points for consideration, Xiao, et al., 1997). Finally, frequent and predictable risks are most

often correctly assessed, detected and recovered. The explanation lies in algorithms developed and the current practice that allow the anaesthetist to identify problems quickly (by information filtering).

7. Conclusion

Two questions were asked at the beginning of this chapter and one aim was pursued. Regarding anticipation performed by anaesthetists, we wanted first to highlight the explicit elements of anticipation. However, the results show that the anaesthetist has on the one hand, explicit predictions about specific events and on the other hand, builds expectations that are not clearly communicated (implicit expectations) but known as points for consideration. This result confirms a certain “risk allostasis” (Fuller, et al., 2008). Further analysis (Neyns, 2011) enables us to explain this risk allostasis through the availability of algorithms developed by scientific societies such as SFAR (French Society of Anaesthesia) or the American Society of Anesthesiologists (ASA). These algorithms allow the anaesthetist to manage promptly when a problem occurs. For example, the management algorithm of malignant hyperthermia describes all the symptoms and strategies to use for stopping the crisis.

Thus, during the consultation all the risks are not assessed but it allows the anaesthetist to put warning on specific problems that may arise. The anaesthetist therefore has a schematic representation and uses generic and abstract plans with a particularisation in real time (Anceaux et al., 2002; Thuilliez et al., 2005; Van Daele & Carpinelli, 2001). This means that during the intervention, this representation is the result of filtering information and a highlighting of risks. Throughout the surgery, the anaesthetist will complete this representation with contextual information. Finally, when a problem occurs, anaesthetists tend to put routines in place to assess the situation (algorithms, hypothesis generation). We also observed, whatever the risks they face (frequent/infrequent, predictable/unpredictable) anaesthetists tend to explain the situation using several hypotheses. This result demonstrates that the situation of anesthesia is a complex situation where multiple variables interact and can be the source of several problems. Moreover, epidemiological studies pointed out that there were problems arising from inadequate evaluation and a bad patient’s preparation for surgery. Our results tend to show that it can only be part of a highlighting of several risks as those actually involved. The anaesthetists’ representation is distorted by some points for consideration when they have to assess the situation. Another study (Neyns, 2011) shows that certain events (such as difficult intubation) could be due to a misidentification according to qualitative judgments on criteria.

But these first results cannot attest to the necessity or not of a preanesthetic consultation but allow to emphasize the importance of the anaesthetists’ experience and the need to develop habits of action (Norros & Klemola, 1999) to recognise and manage some cases. For example, the infrequent risks. Because rare does not mean impossible, it is important to establish some specific training through simulations, conference, seminar, etc. In another study (Neyns, 2011) we compared the risk management between France (with consultation) and Quebec (without specific anaesthesia consultation). This study showed that in Quebec they have developed specific patterns of actions that allow them to quickly manage the problem, even if they took longer time to identify the problem.

This chapter, in line with the work on resilience, contributes to a positive view of risk management in anaesthesia. The operator is a central key to the system resilience, not only in terms of preparation but also in real-time management. It points out adaptation strategies to the system variabilities by a proactive identification of risk factors and reactive strategies in response to changes of the patient's health conditions (Patterson et al., 2010).

Finally, the use of different approaches to address resilience is relevant, it permits to obtain and confront additional information. It is interesting to use several techniques to obtain additional information. However, methods used are subject to numerous biases. The categorization of files can not really be considered as a consultation. The patient was not present, the anesthetist has to build his representation on written data, not physical or verbal ones. In the simulation, the anesthetist is confronted alone to the case but it is a team-work where detection by a third person is very important. Thus, detection strategies could not be identified. Moreover, in this second study, we focused on the risks occurring in the operating room. It is clear that these risks also require increased monitoring after surgery because they can affect the patient's health. However, for purposes of the study, the simulation did not take into account the latter period.

8. Acknowledgment

This research project would not have been possible without the support of many people. The lead author wishes to express her gratitude to her three colleagues, Prof. Dr. Cellier, Dr. Carreras and Ms Planes who offered invaluable assistance, support and guidance in these two studies. She also wishes to thank all the anaesthetists who were abundantly helpful to understand their work. Deepest gratitude are also due to all the members of the Laboratory of Cognition for sharing the literature and invaluable assistance, and the members of the French Society of Anaesthetists without whose knowledge and assistance these studies would not have been successful. The author would also like to convey the Faculty for providing the financial means and laboratory facilities.

Finally, the lead author would also like to express her love and gratitude to her beloved families for their understanding and endless love.

9. References

- Allwood, C.M., & Montgomery, P. (1982). Detection of errors in statistical problem solving. *Scandinavian Journal of Psychology*, 23, 131-139.
- Allwood, C.M. (1984). Error detection processes in statistical problem solving. *Cognitive Science*, 8, 415-437.
- Amalberti R, Auroy Y, Berwick D, Barach P. (2005). Five system barriers to achieving ultrasafe health care. *Ann Intern Med*, 142(9), 756-764.
- Anceaux, F., & Beuscart-Zéphir, M.C. (2002). La consultation préopératoire en anesthésie : gestion de la prise d'informations et rôle des données retenues dans la planification du processus d'anesthésie. *Le Travail Humain*, 65(1), 59-88.
- Anceaux, F., Thuilliez, H., & Beuscart-Zéphir, M.C. (2001). Gestion de la prise d'informations pour la planification en situation dynamique : l'anesthésie. In V.

- Gorsjean & E. Raufaste (Ed.), *Actes des premières journées d'études en Psychologie Ergonomique – Epique 2001*, INRIA, Rocquencourt, pp71-82.
- Arbous, M.S., Grabbee, D.E., Van Kleef, J.W., de Lange, J.J., Spoormans, H.H.A.J.M, Touw, P., Werner, F.M., & Meursing, A.E.E. (2001). Mortality associated with anaesthesia: a qualitative analysis to identify risk factors. *Anesthesia*, 56, 1141-1153.
- Beuscart-Zéphir, M.C., Anceaux, F., Crinquette, V., & Renard, J. (2001). Integrating users' activity modelling in the design and assessment of hospital electronic patient records: the example of anesthesia. *International Journal of Medical Informatics*, 64, 157-171.
- Nyssen, A.-S., & Blavier, A. (2006). Error detection: A study in anaesthesia. *Ergonomics*, 49, (5-6), 517-525.
- Boudes, N., & Cellier, J.M. (1998). Etude du champ d'anticipation dans le contrôle du trafic aérien. *Le Travail Humain*, 61, 29-50.
- Carreras, O., Cellier, J.M., Valax, M.F., & Terrier, P. (2001). Ajustement temporel à la dynamique des situations. *Psychologie Française*, 46(2), 119-129.
- Cellier, J.M., De Keyser, V., & Valot, C. (1996). *La gestion du temps dans les environnements dynamiques*. Paris, Presses Universitaires de France.
- Cellier, J.M., Eyrolle, H., & Mariné, C. (1997). Expertise in dynamic environments. *Ergonomics*, 40, 28-50.
- Chung, D.C., & Lam, A.M. (1990). *Essentials of Anesthesiology* (2 ed.). Philadelphia: W.B. Sanders.
- Cohen, M.M., Duncan, P.G., & Tate, R.B. (1988). Does Anesthesia Contribute to operative mortality ?. *JAMA*, 260 (19), 2859-2863.
- Cook, R.I., & Woods, D.D. (1994). Operating at the sharp end: the complexity of human error. In Bogner M.S. (Ed.). *Human Error in Medicine*. Hillsdale, NJ: Lawrence Erlbaum Associates. pp. 255-310.
- Cooper, J.B., Long, C.D., Newbower, R.S., & Philip, J.H. (1982). Critical incidents associated with intraoperative exchanges of anesthesia personnel. *Anesthesiology*, 56 (6), 456-461.
- Cooper, J.B., Newbower, R.S., & Kitz, R.J. (1984). An analysis of major errors and equipment failures in anesthesia management. Considerations for prevention and detection. *Anesthesiology*, 60, 34-42.
- De Keyser, V., & Nyssen, A.S. (1993). L'erreur humaine en anesthésie. *Le Travail Humain*, 56, 243-266.
- Denecker, P. (1999). Les composantes symboliques et subsymboliques de l'anticipation dans la gestion des situations dynamiques. *Le Travail Humain*, 62 (4), 362-385.
- Finley, G.A. & Cohen, A.J. (1991). Perceived urgency and the anaesthetist: responses to common operating room monitor alarms. *Canadian Journal of Anaesthesia*, 38, 958-964.
- Fuller, R., McHugh, C., & Pender, S. (2008). Task difficulty and risk in the determination of driver behaviour. *European Review of Applied Psychology*, 1, 13-21.
- Gaba, D.M. & Lee, T. (1990). Measuring the workload of the anesthesiologist. *Anesthesia and Analgesia*. 71, 354-361.
- Hoc, J.M. (1995). Planning in diagnosing a slow process: some implications on the design of human operator computer support. *Zeitschrift für Psychologie*, 203, 101-115.

- Hoc, J.-M. (1989). La conduite d'un processus à longs délais de réponse : une activité de diagnostic. *Le Travail Humain*, 52, 289-316.
- Hoc, J.-M. (1987). *Psychologie cognitive de la planification*. Grenoble : Presses Universitaires de Grenoble.
- Hoc, J.-M. (2006). Planning in dynamic situations: some findings in complex supervisory control. In W. van Wezel, R. Jorda, & A. Meystel (Eds.) *Planning in Intelligent Systems : Aspects, Motivations, and Methods*, Hoboken, NJ: John Wiley & Sons.
- Hollnagel, E., Woods, D.D., & Leveson, N., (2006). *Resilience Engineering: Concepts and Precepts*. Aldershot, UK: Ashgate Publishing.
- Lagasse, R.S. (2002). Anesthesia safety : model or myth? A review of the published literature analysis of current original data. *Anesthesiology*, 97, 1609-1617.
- Lebart, L. & Salem, A. (1994). *Statistique Textuelle*, Dunod, 344 p.
- McDonald, J.S. & Dzwonczyk, R. (1988). A time and motion study of the anaesthetist's intraoperative time. *British Journal of Anaesthesiology*. 61, 738-742.
- McDonald, J.S., Dzwonczyk, R., Gupta, B. & Dahl, M. (1990). A second time-study of the anaesthetist's intraoperative period. *British Journal of Anaesthesiology*. 64, 582-585.
- Morel, G., Amalberti, R., & Chauvin, C. (2008a). Articulating the differences between safety and resilience: The decision-making process of professional sea-fishing skippers. *Human Factors*, 50(1), 1-16.
- Morel, G., Amalberti, R., & Chauvin, C. (2008b). Safety and Resilience: Articulation and difference – The example of the professional fishing industry. *Human Factors*, 50 (1), 1-16.
- Neyns, V., Carreras, O., & Cellier, J.M. (2010). Evaluation et gestion des risques en anesthésie : Stratégies mises en place par les médecins-anesthésistes. *Le Travail Humain*, 73 (4), 319-337.
- Neyns, V. (2011). *Les modalités du contrôle cognitif en situation dynamique : anticipation et gestion des dérives. Le cas de l'anesthésie*. Thèse de doctorat, Université de Toulouse.
- Norros, L., & Klemola, U.M. (1999). Methodological considerations in analysing anaesthetists' habits of action in clinical situations. *Ergonomics*, 42 (11), 1521-1530.
- Nyssen, A.S., & De Keyser, V. (1998). Improving training in problem solving skills: Analysis of anesthetists' performance in simulated problem situations. *Le Travail Humain*, 61(4), 387-401.
- Nyssen, A.S. (1997). Une nouvelle approche de l'erreur humaine dans les systèmes complexes : Exploration des systèmes complexes en anesthésie. Thèse de doctorant en Psychologie, non publiée, Université de Liège, Liège.
- Patterson, E.S., Cook, R.I., Woods, D.D., & Render, M.L. (2010). Gaps and resilience. In M.S. Bogner (Ed.), *Human error in medicine*, (second edition ed.).
- Planes, L. (2011). Comparaison de verbalisations d'anesthésistes experts et novices. Mémoire de Master 1: Sciences du langage/Traitement automatique des langues. Université de Toulouse.
- Reason, J. (2008). *The Human Contribution: Unsafe Acts, Accidents and Heroic Recoveries*. Ashgate Editions.
- Reason, J. (1990). *Human Error*. Cambridge: Cambridge University Press.
- Rimoldi, H.J.A. (1963). Processus de décision et fonctions mentales complexes. *Revue européenne de psychologie appliquée*, 54, 25-32.

- Rizzo, A., Bagnara, S., & Visciola, M. (1987). Human error and detection processes. *International Journal of Man-Machine Studies*, 27, 555-570.
- Rizzo, A., Ferrante, D., & Bagnara, S. (1995). Handling human error. In J.M. Hoc, & P.C. Cacciabue (Eds.), *Expertise and Technology: Cognition and Human-computer Cooperation. Expertise: Research and Applications*, NJ: Lawrence Erlbaum Associates, pp. 195-212.
- Sellen, A.J., & Norman, D.A. (1992). The psychology of slips. In B.J. Barrs (Eds.), *Experimental Slips: Exploring the Architecture of Volition*. New York: Plenum Press, pp. 317-339.
- Sellen, A.J. (1990). Mechanisms of human error and human error detection, PhD thesis, University of California, San Diego (published 1991), University Microfilms, *Abstract in Dissertation Abstracts International*, 51, 5618.
- Sellen, A.J. (1994). Detection of everyday errors. *Applied Psychology: An International Review*, 43, 475-498.
- Sfez, M. (2002). Analyse et maîtrise du risque en anesthésie. *Conférences d'actualisation*, 371-385. (http://www.anesthesie-foch.org/s/article.php3?id_article=138)
- Sfez, M., de Marcellis-Warin, N., Pourreau, A., Triadou, P., Courault, M. & Lienhart, A. (2008). Combiner entretiens et cas simulé pour identifier les facteurs favorisant la récupération. *Risques et Qualité*, 5(3).
- Thuilliez, H., Anceaux, F., & Hoc, J.M. (2005). Rôle de l'opérateur et du statut fonctionnel des informations lors de la prise d'informations en anesthésie. *Le Travail Humain*, 68, 225-252.
- Van Daele, A., Carpinelli, F. (2001). La planification dans la gestion des environnements dynamiques : quelques apports récents de la psychologie ergonomique. *Psychologie Française*, 46 (2), 143-152.
- Vicente, K.J. (1999). *Cognitive Work Analysis: Toward safe, productive, and healthy computer-based work*. Mahwah, NJ: Lawrence Erlbaum Associates.
- Woods, D. (1984). Some results on operator performance in emergency events. *Institute of Chemical Engineers Symposium*, 90, pp. 21-23. Columbus, OH: Ohio State University.
- Woods, D.D. (1988). Coping with complexity: The psychology of human behavior in complex systems. In L.P. Goodstein, H.B. Andersen, and S.E. Olsen, (Eds.). *Tasks, Errors and Mental Models*. New York: Taylor & Francis.
- Xiao, Y. (1994). Interacting with complex work environment: A field study and a planning model. Ph.D. Dissertation, University of Toronto, Ontario, Canada.
- Xiao, Y., Milgram, P., & Doyle, D.J. (1997). Planning behavior and its functional rôle in interactions with complex systems. *IEEE Transactions on Systems, Man and Cybernetics, Part A*, 27(3), 313-324.
- Zapf, D., & Reason, J.T. (1994). Introduction: Human errors and error handling. *Applied Psychology: An International Review*, 43, 427-432.
- Zhang, J., Patel, V.L., & Johnson, T.R. (2002). Medical Error: Is the Solution Medical or Cognitive? *Journal of the American Medical Informatics Association*, 9(6), s75-s77.



Novel Approaches and Their Applications in Risk Assessment

Edited by Dr. Yuzhou Luo

ISBN 978-953-51-0519-0

Hard cover, 344 pages

Publisher InTech

Published online 20, April, 2012

Published in print edition April, 2012

Risk assessment is a critical component in the evaluation and protection of natural or anthropogenic systems. Conventionally, risk assessment is involved with some essential steps such as the identification of problem, risk evaluation, and assessment review. Other novel approaches are also discussed in the book chapters. This book is compiled to communicate the latest information on risk assessment approaches and their effectiveness. Presented materials cover subjects from environmental quality to human health protection.

How to reference

In order to correctly reference this scholarly work, feel free to copy and paste the following:

Valérie Neyns, Ophélie Carreras, Laurie Planes and Jean-Marie Cellier (2012). Risk Assessment in the Anaesthesia Process, Novel Approaches and Their Applications in Risk Assessment, Dr. Yuzhou Luo (Ed.), ISBN: 978-953-51-0519-0, InTech, Available from: <http://www.intechopen.com/books/novel-approaches-and-their-applications-in-risk-assessment/risk-assessment-and-anaesthesia-in-france-the-cognitive-point-of-view>

INTECH
open science | open minds

InTech Europe

University Campus STeP Ri
Slavka Krautzeka 83/A
51000 Rijeka, Croatia
Phone: +385 (51) 770 447
Fax: +385 (51) 686 166
www.intechopen.com

InTech China

Unit 405, Office Block, Hotel Equatorial Shanghai
No.65, Yan An Road (West), Shanghai, 200040, China
中国上海市延安西路65号上海国际贵都大饭店办公楼405单元
Phone: +86-21-62489820
Fax: +86-21-62489821

© 2012 The Author(s). Licensee IntechOpen. This is an open access article distributed under the terms of the [Creative Commons Attribution 3.0 License](https://creativecommons.org/licenses/by/3.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

IntechOpen

IntechOpen