



Original Article

Use of volatile anaesthetic agents in anaesthesia: A survey of practice in France in 2012[☆]



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ARTICLE INFO

Article history:

Available online 23 May 2015

Keywords:

Desflurane

Pharmacology

Initial and continued training

Anaesthetic practice

ABSTRACT

Volatile anaesthetic agents are used in the vast majority of general anaesthetics performed in France. We assessed the degree of understanding of French anaesthetists with regard to the general pharmacology of these products and their understanding of the factors that govern selection of the different agents available for use in adults. A validated 13-item questionnaire was sent electronically in 2012 using files from the *Société française d'anesthésie et de réanimation* (Sfar). It covered four categories: general characteristics of the respondent; practical aspects of anaesthesia with volatile agents; pharmacological properties and criteria for choosing a volatile agent; risk of intra-operative awareness. Among the 981 respondents, the anaesthetic technique used by 50% was that of an intravenous induction followed by maintenance with sevoflurane. The concepts relating to the practical use of these products are well known. A fresh gas flow of less than 2 L/min is used by 96% of the respondents. However, knowledge levels are often inadequate (rate of correct answers often < 50%). This lack of knowledge pertains to current themes (climate pollution), those of debatable clinical significance, e.g. pre-conditioning, hypoxic vasoconstriction and those that concern scientific theory (medullary action). However, a lack of knowledge is also observed with regard to basic pharmacology (respiratory, vascular, neurological or pharmacokinetic effects). There is no significant difference in the mode of practice. The experience of the anaesthetist (measured by number of years post diploma) resulted in a number of differences in response to many aspects of the questionnaire but these were minor. These results suggest the need for an improvement both in the initial and continued training of anaesthetists with respect to volatile anaesthetic agents.

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1. Introduction

Volatile anaesthetics agents are used daily in the vast majority of general anaesthetics performed in France. The “new” volatile anaesthetic agents (desflurane and sevoflurane) have in fact been available for quite some time [1,2] and if there was initially some resistance to their use [3], mainly due to the extra cost with which

they were associated, they are now widely used. As commonly used products, they are no longer widely questioned. We wanted to assess the degree of knowledge of practitioners concerning the general pharmacology of these products and understand those factors that govern their selection of different products. An electronic survey was therefore carried out in 2012 in order to answer these questions.

2. Methods

The questionnaire¹ was prepared by a working group of experts in the pharmacology of anaesthesia. The questionnaire was

[☆] This work was supported by a grant to the *Société française d'anesthésie et de réanimation* (Sfar). AbbVie Laboratories did not participate in the questionnaire design, the interpretation of data or in the writing of the article.

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¹ <http://enquetes.sfar.org/limesurvey/index.php?sid=89117&lang=fr>.

preceded by a short text explaining that the survey was being conducted under the auspices of the Sfar, the goal being to test theoretical knowledge about these products and to determine the methods used when choosing a volatile anaesthetic agent. The time to complete the questionnaire was short, being approximately 5 minutes. The questionnaire was designed to explore practice in adults, the paediatric field having recently been evaluated by Constant et al. [4]. Thus, the questionnaire included only one specific paediatric question to test the comparability with previous data. The issues explored were the pharmacological effects of volatile anaesthetic agents in general and the specific effects of desflurane and sevoflurane. Questions about other volatile anaesthetic agents were not included.

The questionnaire included 13 questions and was divided into four categories: general characteristics of the respondent; practical aspects of anaesthesia with volatile anaesthetic agents and their pharmacological properties; the criteria employed when choosing a volatile anaesthetic agent; the risk of intra-operative awareness. The later two questions, although not specifically related to the use of volatile anaesthetic agents, were approved by the working group in order to determine whether a future survey on this subject would yield interesting results. We subsequently show that this is indeed the case.

The questionnaire was converted into an electronic version using LimeSurvey[®]. Prior to the launch of the study, the questionnaire was trialled by ten anaesthetists working in Sfar committees to validate and ensure understanding of the questions, and ensure there were no difficulties in filling out the questionnaire. No changes were necessary after the test phase. An e-mail was then sent to all anaesthetists on the mailing list for the Sfar, which is approximately 14,000 email addresses. On receiving the email, a link to the questionnaire allowed the respondent to anonymously complete the survey. The online questionnaire was conducted in July 2012, with a re-launch performed one month later.

Responses were compared either to a reference when possible or to answers generated by the expert working group. In the latter case, the appropriate response was the result of a consensus among experts if responses initially differed. Results were requested either in a descriptive manner or, for all closed questions, in absolute numbers or percentages. The Chi² test was used when comparing the results according to location performance and seniority of diploma. A difference was considered to be significant for a value of $P < 0.05$.

3. Results

Characteristics of the 981 anaesthetists who responded to the questionnaire are summarised in Table 1. Two-thirds of anaesthetists were working in the public sector and more than half had been board certified anaesthetists for more than ten years. One question explored the technique of general anaesthesia most commonly used in adult patients requiring inpatient surgery. The method used by nearly 50% of respondents was intravenous induction followed by sevoflurane maintenance. Intravenous induction followed by desflurane maintenance was used by 24% of respondents while total intravenous anaesthesia (TIVA) was used regularly by 17% of respondents. The distribution of responses for day-case surgery shows minor differences (Table 2). In children, 88% of practitioners do not switch to desflurane after induction with sevoflurane. Desflurane was used by 10% when the duration of anaesthesia was expected to be longer than 90 minutes and if the child did not have bronchial hyperactivity. Questions assessing the comparative pharmacological properties of the two products are shown in Table 3. Broadly speaking, desflurane was considered

Table 1
Respondents characteristics.

Questions	Responses (n)	Responses (%)
<i>Current Status</i>		
Internship	91	9
Fellowship post-internship	91	9
Hospital practitioner or other "full-time practitioner"	474	27
Professor	61	6
Private practitioner	264	26
<i>Location of practice</i>		
Public hospital	615	63
Private hospital	258	26
Mixture of private and public hospitals	44	5
Non-profit private institutions (e.g. ESPIC ^a)	44	5
Locum	14	1
<i>Number of years with diploma</i>		
< 5 years	292	30
5–10 years	119	12
> 10 years	570	58

Percentages are rounded to the nearest whole number depending on whether the value after the decimal is greater than or less than 5.

^a *Établissements de santé privés à but non lucratif.*

to be expensive, allow a rapid recovery, and to be irritating to the airways. Half of the respondents associated it with good haemodynamic and metabolic tolerance. Approximately 20% of respondents thought that desflurane was associated with effective pharmacological pre-conditioning. Responses to questions about sevoflurane mirrored that of desflurane with respect to time to emergence from anaesthesia and effects on the airways. With respect to other properties, haemodynamic and metabolic tolerance was thought to well describe both drugs for 50% of respondents. Approximately half of the respondents said sevoflurane provides haemodynamic stability, is well tolerated metabolically and confers a degree of pre-conditioning and is not expensive. Comparing desflurane and sevoflurane did not disclose a frank difference in favour of one drug, except for rapid awakening and metabolic tolerance, both properties favouring desflurane. In addition, except for the irritating effect of volatile agents, no other property clearly differentiated them from intravenous agents, with almost half of respondents preferring volatile and the other half preferring intravenous agents.

More than half (54%) of respondents said that increased heart rate accelerates the induction of anaesthesia induced by volatile anaesthetic agents. A majority (75%) of respondents said that formation of compound A results from sevoflurane coming into contact with soda lime. Approximately 19% know that a rapid increase in desflurane concentration is associated with blood pressure elevation and 42% responded that volatile anaesthetic

Table 2
General anaesthesia technique in adults according to mode of hospitalisation.

Responses (%)	Conventional hospitalisation	Day-case surgery
IV induction and maintenance with sevoflurane	48	42
IV induction and maintenance with desflurane	24	23
Total intravenous anaesthesia (TIVA)	17	22
Induction with sevoflurane and maintenance with sevoflurane	2	–
Other	8	11

Percentages are rounded to the nearest whole number depending on whether the value after the decimal is greater than or less than 5.

Table 3

Perception of respondents with respect to the general pharmacological properties of desflurane and sevoflurane; preference of respondents comparing sevoflurane and desflurane; comparison of preference of inhalational volatile anaesthetic agents with intravenous agents^(a).

Pharmacological property	Well describes desflurane (% positive responses)	Well describes sevoflurane (% positive responses)	Preference for sevoflurane over desflurane (% positive responses)	Preference for volatile anaesthetic agents over IV agents ^a (% positive responses)
Rapid awakening	80	32	12	55
Irritant effect on the airways	72	7	55	18
Haemodynamic tolerance	50	55	31	49
Metabolic tolerance	51	42	19	32
Pre-conditioning effect	20	50	45	58
Low cost	16	46	48	44

Percentages are rounded to the nearest whole number depending on whether the value after the decimal is greater than or less than 5.

agents inhibit hypoxic pulmonary vasoconstriction. Peri-operative immobility secondary to volatile anaesthetic agents was attributed to their action on the spinal cord by 10% of respondents and 21% believe that sevoflurane is contra-indicated in neurosurgery. Almost two-thirds of respondents (62%) consider that volatile anaesthetic agents are more likely to raise intracranial pressure in comparison with intravenous agents but did not consider one particular agent to be more or less effective. Sevoflurane may be used during cardiopulmonary bypass for 34% percent of respondents. One third (30%) of respondents believe that sevoflurane provides better protection against the effects of ischaemia-reperfusion in liver surgery than propofol. The meaning of the acronym AINOC (*anesthésie inhalée à objectif de concentration* = target controlled inhalational anaesthesia) is known by 67% of respondents respectively. A fresh gas flow of < 1 L/min and < 2 L/min was used by 53 and 43% of respondents respectively. Finally, 61% of respondents considered that volatile anaesthetic agents result in pollution of the operating theatre, even at low fresh gas flows.

Half of the respondents (51%) had never encountered a case of peri-operative awareness and less than 1% of them considered it to be a common occurrence in their practice. Attempts to prevent intra-operative awareness were through a deepening of anaesthesia (67%), use of adjunctive hypnotics or opioids (44%), pre-operative evaluation of risk factors (45%), adequate filling of the vaporiser pre-operatively to prevent the need during surgery (45%) and the use of depth of anaesthesia monitoring (80%). There is no significant difference in these responses depending on the mode of anaesthetic delivery (data not shown). The length of anaesthetic experience impacts on many aspects of the questionnaire but the differences are not significant (i.e. < 10% difference between younger and older anaesthetists) except in a small number of variables: effect of pre-conditioning with volatile anaesthetic agents (volatile anaesthetic agents more effective with respect to pre-conditioning than intravenous agent: 72% vs. 48%; < 5 years vs. > 10 years; $P < 0.05$) and sevoflurane in particular is better known by the younger anaesthetist (56 versus 36%; < 5 years vs. > 10 years; $P < 0.05$). The search for risk factors for awareness was more often considered to be important by the younger anaesthetists (61% vs. 36%; < 5 years vs. > 10 years; $P < 0.05$). Finally, the use of specific monitoring of depth of anaesthesia as a means of preventing awareness is more popular with younger anaesthetists (87 vs. 75%; < 5 years vs. > 10 years; $P < 0.05$).

4. Discussion

This survey of volatile anaesthetic agents was designed to test theoretical knowledge about these products and to specify the methods employed when choosing a volatile agent. The results are

quite mixed but generally show a superficial or even insufficient knowledge, with little evidence of practical integration of the most recent literature. Few differences separate private practitioners from those working in the public sector and the level of knowledge is better in younger anaesthetists in only a few respects.

The absolute number of respondents was high (approximately 1000), although the response rate was not (1000/14,000).² It is clear that for anaesthetists who primarily practice intensive care medicine, the questionnaire was of limited use and interest. We cannot definitively say that the responses are representative of the practice of French anaesthetists in general but there are elements to suggest this is a representative sample. Firstly, the proportion of respondents from the public sector is about 65% versus 30% for the private sector and the Sfar survey figures from 1999 [5] show a similar demographic distribution with 37% working at least partly in private practice and 63% practicing in the public sector. These data are confirmed by more recent results³ showing that among anaesthetists practicing in 2010, 65% are employed within a trust or hospital system and 31% work privately. These arguments make it likely our sample is representative. If one excludes those respondents (approximately 20%) using TIVA or regional anaesthesia, our results show a distribution for the use of sevoflurane:desflurane of 58%:30%. This ratio is close enough to data collected by GERS,⁴ which found the ratio of bottles sold to be 79%:20% for the two volatile anaesthetic agents. GERS data also validate the need to focus the questionnaire on these two volatiles, use of the other anaesthetic agents being much less. In our survey, we also found that approximately 95% of respondents use sevoflurane to maintain anaesthesia in children. These results are similar to the study of Constant et al. [4], which showed that in 80–93% of paediatric anaesthesia, the agent sevoflurane is used for maintenance.

² The mailing list for the Sfar includes mainly the addresses of anaesthetists but also those of nurse anaesthetists. In the absence of information available in the files on the status of the recipient, it was impossible to selectively send to just anaesthetists. However, as the question about status asked specifically about medical occupation, other categories of respondents were excluded.

³ Romestaing P. (President of the French General Medical Council – *Conseil national de l'Ordre des médecins*). *Démographie médicale des spécialistes intervenants au Bloc opératoire, colloque au Sénat, 6 avril 2012.*

⁴ The GERS (*Groupement pour l'élaboration et la réalisation de statistiques*), an economic interest group (EIG), created by the pharmaceuticals industry, includes members from almost all of the French pharmaceutical laboratories. It conceives, generates, and disseminates sales statistics for pharmaceutical products for the use of its members nationwide. It also manages their databases. The GERS' statistics are not gathered by surveys; they are exact complete series based on sales figures. They are gathered from distribution organisations and are taken from delivery information for pharmacies, from wholesalers' records of the sales made directly to pharmacies and from the hospital laboratories they order from, as well as from the laboratories' own records of sales to pharmacies, hospitals, and foreign markets. The data presented has been kindly provided by the AbbVie[®] laboratory.

Some of the classic concepts are well recognised, notably those related to the practical use of these products. More than 90% of respondents clearly indicate that they use low fresh gas flows (FGF < 2 L/min). The notion of a closed circuit seems to be well understood and accepted. Half of those anaesthetists using a closed circuit use a FGF between 1 and 2 L/min. This is probably explained by the fact that anaesthesia machines currently in use in most theatres do not allow very low FGFs. The majority (80%) of respondents know that compound A is formed when sevoflurane comes into contact with soda lime. Desflurane is more quickly removed from the body than sevoflurane but it is of note that the percentage of use of desflurane in day-case anaesthesia has not increased (relative to its use in inpatient surgery). There are many factors which could explain this: the duration of the surgery does not allow for a detection of difference (the more lipophilic sevoflurane does not have sufficient time to significantly accumulate); anaesthetists alter their practice to take into account the differences in characteristics; the establishment has only one inhalational agent available for use; the use of laryngeal masks leads to a greater use of sevoflurane. This last hypothesis is plausible because use of desflurane for anaesthesia maintenance in a patient with a laryngeal mask does not expose them to more respiratory complications than use of sevoflurane [6] but this is often not recognised. Rightly, the cost of desflurane is often estimated to be higher than that of sevoflurane. The price of desflurane per mL is slightly higher than that of sevoflurane: the main reason for the increased cost is its higher MAC value [7]. Our survey demonstrates an incomplete level of knowledge, which in some respects, is more understandable because the topics are newer (volatile anaesthetic agents and climate pollution [8], meaning of the acronym AINOC), of questionable clinical significance (pre-conditioning [[9], hypoxic vasoconstriction [10]] or of largely theoretical scientific value (spinal action of volatile inhalational agents [11]). However, there also appears to be a deficit in more basic knowledge (arguably forgotten or never learned). For instance, on questioning about the effect of increased cardiac output on induction time, 54% of respondents said that it accelerates induction, while in fact it reduces the alveolar concentration: inspired concentration ratio thus slowing the attainment of effective alveolar concentration, unlike an increase in ventilation [12]. It is also surprising to find that nearly 10% of respondents view sevoflurane as an “irritant” to airways. Are we to understand that recognition of an odour would lead us to assume an irritant effect? Approximately 20% of respondents consider volatile anaesthetic agents to be contraindicated in neurosurgery; this response appears to be related to their effect on intracranial pressure. Although inhalational agents do result in cerebral vasodilatation and are therefore likely to increase intracranial pressure, this is only a significant problem if the fraction of volatile agent used is high (i.e. > 1 MAC approx) [13–15]. Finally, the vast majority of respondents (90%) do not know that a rapid increase in the concentration of desflurane may be associated with sympathetic stimulation and hypertension [16].

We identified differences in responses depending on certain factors pertaining to the respondents, for example the number of years post diploma seems to have played a part. Although younger anaesthetists represent only 10% of the population of French anaesthetists and intensive care physicians [17], their response rate to the questionnaire was higher, representing approximately half of the respondents. Overall, knowledge and practice are somewhat different in many aspects. We identified a few areas in which the younger anaesthetists (< 5 years since gaining their diploma) had a higher number of correct answers: the case of the pre-conditioning effect of volatile inhalational agents and

sevoflurane in particular. This difference is probably related to the recent nature of the literature on this subject [9]. However, although more of the younger anaesthetists seem to pay greater attention to risk factors for awareness, they are also more likely to think that monitoring prevents its occurrence. This suggests that knowledge acquired during training is not significantly challenged. In fact, the beneficial effect of BIS monitoring, which was widely agreed on a few years ago, has recently been re-evaluated showing its use to have little effect on the incidence of awareness [18]. This change in current thinking does not appear to have been recognised by the younger anaesthetists. With respect to awareness, one is struck by the fact that approximately one third of respondents do not believe that deepening anaesthesia alters the risk of awareness and half of the respondents do not know that re-filling the vaporiser during surgery may increase the risk of awareness [19]. Yet this pertains to situations encountered on a daily basis. These results could be explained by the fact that the occurrence of awareness is rare (approximately 1–2/1000 general anaesthetics) and that most anaesthetists receive little feedback on what happens in the days following surgery. Additionally most patients do not mention to their doctors that they have experienced awareness (unless directly asked); thus nobody is informed of the occurrence of awareness. Since awareness is perceived as rarely occurring, methods for prevention are not well understood.

This study has several limitations that must be taken into account in the analysis. If we consider that anaesthetists in France obtain their diploma when they are approximately 30 years old, our results indicate that the median time since gaining this qualification was 10 years, approximating our respondents' median age to be 40 years. In other surveys, the average age of anaesthetists was 46 in 1996 and 51 in 2010 [20]. Therefore, the respondents in our survey seem rather younger than the general population of French anaesthetists.

Other limitations are related to the structure of the questionnaire and the survey. We chose a questionnaire assessing many areas, thus allowing only a small amount of exploration per area. A longer questionnaire would probably lead to a lower response rate. If we had focused on a specific topic, we could probably have better assessed knowledge of that topic but would have been unable to explore the general knowledge of volatile anaesthetic agents. Certain questions comparing desflurane and sevoflurane indicate if one agent is favoured over the other, but do not reveal whether the answer is correct in totality. Thus, 46% of respondents consider sevoflurane as inexpensive while 16% consider desflurane as inexpensive. However, if the question had included isoflurane, both products would probably have been considered expensive. The inclusion of a question exploring paediatric practice might have been confusing about the population explored but we were reassured that answers to that question were consistent with the previous survey by Constant et al. [4] on one hand, and that other responses describing the use of these drugs were in line with adult practice on the other hand.

The questionnaire was not intended for nurse-anaesthetists.² Although the questionnaire was designed for physicians, it is certainly a shame not to know what this group thinks or knows about the subject, considering the important role they play in the choice of volatile anaesthetic agents in operating theatres across France.

Finally, the terminology did not appear to be clear in some cases despite the pre-survey testing. The meaning of the word “neutral” used in the desflurane and sevoflurane comparisons could well be interpreted as indicating: “I do not know” or “I do not care”. This cannot be determined but these potentially different interpretations may reflect different levels of understanding.

5. Conclusion

This questionnaire covered many aspects relating to the knowledge and use of modern volatile anaesthetic agents. The overall results show adequate knowledge for the daily practice of safe anaesthesia but an acceptance of superficial or even insufficient knowledge on recent developments. Few differences were found between the various categories of anaesthetists. These results suggest, therefore, the need to strengthen initial training and to continue education about anaesthetic products in daily use.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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