General anaesthesia for external electrical cardioversion of atrial fibrillation: experience of an exclusively cardiological procedural management

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Received 4 March 2010; accepted after revision 1 July 2010; online publish-ahead-of-print 16 August 2010

Aims
External electrical cardioversion (EC) usually requires brief general anaesthesia involving anaesthetists. The aim of this study was to evaluate the feasibility and safety of inducing anaesthesia for EC of atrial fibrillation (AF) exclusively by the cardiology team with anaesthetists on-hand.

Methods and results
A retrospective analysis of 624 elective EC, over a 6-year period, was made. No patients were excluded due to the severity of pathology or comorbidities. The protocol of the intravenous anaesthesia was 5 mg bolus of midazolam and subsequent increasing doses of propofol starting from 20 mg to achieve the desired sedation level. After delivering DC shock, a direct observation period followed in order to assess the post-sedation recovery and to detect the procedure-related complications. Electrical cardioversion was effective in 98.9% of the cases. General anaesthesia was effective in 100% of cases with a dosage of propofol, ranging between 20 mg to a maximum of 80 mg, after 5 mg of midazolam was administered. All patients generally showed a fast recovery waking up in a few minutes. The anaesthesiology team was never called for assistance. All the procedures were carried out by the cardiology team as planned. No thrombo-embolic and allergic complications were observed. Arrhythmic complications were uncommon and essentially bradyarrhythmias.

Conclusion
A general anaesthesia for outpatient EC of AF can be safely handled by a cardiologist having adequate experience with anaesthetic agents. Moreover, the association of midazolam and a very small dosage of propofol, given their synergic action, is effective and safe in inducing anaesthesia. Arrhythmic complications are rare and limited to bradyarrhythmias.

Keywords
Electrical cardioversion • Atrial fibrillation • Anaesthesia

Background
Electrical cardioversion (EC), after many years since its first use, continues to have an important role in daily practice, especially in the setting of atrial fibrillation (AF) management. Prevalence and incidence of AF are increasing, and restoring sinus rhythm remains a goal for the clinician.

External EC is a short but painful procedure. It requires general anaesthesia or at least deep sedation. Analgesia, amnesia induction, and fast and complete recovery are the principal characteristics of anaesthesia for brief procedures, often carried out as day case procedures. Various short-acting drugs have been tested for this purpose, each of them having some advantages and some disadvantages.

General anaesthesia is traditionally carried out by the anaesthesiology team.

Coordination of the cardiology and the anaesthesiology teams often involves some logistical problems that may create increasing waiting time, low patient satisfaction, and above all, increased costs. This issue is particularly present in this era of limited resources.
Various studies have considered this aspect, but there are still some serious concerns about the safety of anaesthetic drug administration in the absence of the assistance of an anaesthetist.\textsuperscript{7,8}

The aim of this single-centre retrospective study is to report the efficacy and safety of a synergic combination of midazolam and propofol administered to induce anaesthesia in a large population of outpatients undergoing EC.

We also evaluate the feasibility and safety of an exclusively cardiological procedural management with anaesthesiologists on-hand.

**Methods**

We performed 624 elective EC procedures, on 520 consecutive outpatients, over a 6-year period (between 2002 and 2008).

All patients with persistent AF or atrial flutter (AFL), diagnosed following Gallagher’s definition,\textsuperscript{9} and consecutively admitted to our Cardiology Division to undergo EC in outpatient settings were considered.

Admission was scheduled at 8:00 a.m. and discharge within 2–4 h after the procedure. After collecting the clinical history, each patient underwent physical examination and blood pressure measurement. An electrocardiogram (ECG) was performed and a blood sample was taken to obtain haemochrome, electrolytes, creatinine, and coagulation.

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A transthoracic echocardiogram was provided to the patients, and left ventricular systolic function was defined by a semiquantitative method assigning a numerical score.\textsuperscript{10} All patients gave written informed consent before the procedure.

The procedure was performed in a day-surgery room with monitoring and resuscitation equipment.

A brief direct observation of the patient after shock to assess the complete recovery from anaesthesia and verifying optimal recuperation of walking capability were mandatory before discharge.

The team performing the procedure was composed of a cardiologist, electrophysiologist, and a nurse trained to carry out resuscitation.

The anaesthesiology team was not directly involved in the procedure but was on-hand in the case of any emergency.

Exclusion criteria were inadequate anticoagulation and/or high cardioembolic risk (atrial thrombosis) and overt hyperthyroidism.

Poor systolic function at echocardiogram was never considered an exclusion criterion for the procedure.

With regard to intravenous anaesthesia, patients with known or suspected allergy or adverse reaction to midazolam and/or propofol or to its excipients, severe obesity with or without obstructive sleep apnoea, respiratory disease or history of sleep apnoea, history of dementia or seizures, alcoholism, and severe or acute impairment of renal or liver function were excluded. In these cases, the procedure of EC, if not postponable, was performed with the assistance of the anaesthesiologist.

Our protocol includes 5 mg bolus of midazolam and subsequently increasing the doses of propofol (in 20 mL vials containing emulsion to a concentration of 10 mg/mL), starting from 20 mg, to achieve the desired sedation level. The level of sedation was continually monitored throughout. After 2 min from administration of the first bolus, we could choose whether or not to repeat a new bolus (at incremental steps of 10 mg) to reach the optimal level of sedation.

Flumazenil (0.5–1 mg i.v.) was generally administered after shock to antagonize the effect of midazolam.

Blood pressure was measured before and after the procedure, whereas pulse oximetry, measuring transdermal oxygen saturation, and cardiac rhythm were continuously monitored throughout.

Oxygen supplementation with a 100% oxygen mixture was granted to all patients, and ventilation support (manual ventilation) was given if respiratory depression or apnoea occurred in order to maintain a good oximetry.

The level of sedation was continuously assessed by the team throughout the procedure according to the Glasgow coma score modified by Cook and Palma.\textsuperscript{13} The score of the scale, ranging between 4 and 18, is based on the best reactivity response and assess a numerical score that correspond to deep sedation when <8, to mild sedation when in the range between 8 and 13, and to awake status when >13.

Once the optimal level of sedation was achieved an R-wave synchronized biphasic DC shock was delivered and, if ineffective, it possibly might have to be repeated changing paddles position (step-up energy protocol: 120, 150, and 200 J). Energy required for cardioversion was registered. All the procedures were performed with a biphasic defibrillator (Zoll M-Series, Zoll Medical Corporation, Chelmsford, MA, USA) using self-adhesive pads in an anteroposterior position.

Post-sedation recovery was continually assessed by the team, from recuperation of a good spontaneous respiration and return to the baseline levels of \(\text{PO}_2\) to recovery of blood pressure, vital signs, consciousness, response to simple orders, until total recuperation.

Before discharge, generally no less than 2–4 h after the procedure, the team confirmed a complete recuperation of capacity to walk and an ECG was performed. Patients were told not to drive or to undertake complex activities for \(\sim 24\) h after the procedure. Active involvement of familiars was required during the recovery period after shock within hospital observation, by talking with the patient so as to monitor their cognitive status.

Finally, we gave the patients written instructions regarding drug therapy and follow-up.

The same team performed the procedures during all the 6-year observation period with high standardization of the procedural method.

**Anticoagulation**

Anticoagulation was considered adequate when international normalized ratio (INR) values were therapeutic (INR range: 2–3) for at least 3 consecutive weeks, according to the AHA/ACC guidelines.\textsuperscript{11} A transoesophageal echocardiogram was provided in the case of inadequate anticoagulation.\textsuperscript{12} Alternatively, the procedure was postponed until after a sufficient period of optimal anticoagulation.

**Sedation and electrical cardioversion**

Agents used for deep sedation were midazolam [8-chloro-6-(2-fluorophenyl)-1-methyl-4H-imidazo benzodiazepine hydrochloride] and propofol (2,6-disoproplyphenol).

**Statistical analysis**

Data analysis was performed with a statistical software package (Statview 4.5, Abacus Concepts Inc., Berkley, CA, USA). Comparisons between groups were conducted by Student’s t-test for unpaired data. Continuous variables are expressed as mean SD. Chi-square test was performed for nominal data. Continuous data are showed as mean SD. Categorical variables are expressed as numbers and percentages of the total. Logistic regression analysis was used to analyse the predictors of successful EC and of procedural complications (binary variables). A P-value of <0.05 was considered statistically significant.
Results

We performed 624 elective EC procedures for AF on 520 patients (procedures/patient ratio 1.20) in an outpatient setting over a 6-year period (between 2002 and 2008). Demographic characteristics and principal underlying heart diseases of the study population are summarized in Table 1.

Electrical cardioversion was effective in 98.9% of the cases, and in 31 procedures (0.5% of restored sinus rhythm), immediate recurrence of AF was observed.

A logistic regression analysis was conducted to test some variables as predictors of successful cardioversion (Table 2).

General anaesthesia was effective in 100% of cases (the Glasgow coma score ranging between 8 and 10) at a dosage of propofol, ranging between 20 mg and a maximum of 80 mg (28.7 ± 12.7 SD), after 5 mg of midazolam was administered.

No procedure was abandoned because inadequate sedation and no oversedation phenomenon occurred.

The procedure was always well-tolerated; dreaming was common and all patients showed amnesia regarding shock. No memory of pain was reported.

Adverse reaction to anaesthesia

There was no adverse reaction to propofol or midazolam.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Baseline characteristics of patients (total 520 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (mean ± SD years)</td>
<td>67.8 ± 9.2</td>
</tr>
<tr>
<td>Male sex [n (%)]</td>
<td>375 (71.1)</td>
</tr>
<tr>
<td>Hypertension [n (%)]</td>
<td>305 (58.6)</td>
</tr>
<tr>
<td>Valvular heart disease [n (%)]</td>
<td>72 (13.8)</td>
</tr>
<tr>
<td>CAD [n (%)]</td>
<td>120 (23.0)</td>
</tr>
<tr>
<td>Idiopathic cardiomyopathy [n (%)]</td>
<td>13 (2.5)</td>
</tr>
<tr>
<td>Lone atrial fibrillation [n (%)]</td>
<td>4 (0.7)</td>
</tr>
<tr>
<td>PM/ICD [n (%)]</td>
<td>30 (5.7)</td>
</tr>
<tr>
<td>Diabetes [n (%)]</td>
<td>41 (7.9)</td>
</tr>
<tr>
<td>Dyslipidemia [n (%)]</td>
<td>115 (22.1)</td>
</tr>
<tr>
<td>Dysthyroidism [n (%)]</td>
<td>21 (4.0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Predictors of success of electrical cardioversion (DC-shock; univariate logistic regression analysis)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>P-value</td>
</tr>
<tr>
<td>Age</td>
<td>0.18</td>
</tr>
<tr>
<td>Resting heart rate</td>
<td>0.4</td>
</tr>
<tr>
<td>Left ventricular function score</td>
<td>0.7</td>
</tr>
<tr>
<td>Aetiology (ischaemic or not ischaemic)</td>
<td>0.9</td>
</tr>
</tbody>
</table>

A possible transient drop of pO2 at transdermal oxipulsimeter, due to initial respiratory depression, was easily corrected by oxygen supplementation. Apnoea, a very uncommon and transitory event in our population (<3%), has always been easily managed with manual ventilation using the bag-mask-valve device providing 100% O2.

Intubation was never required nor any electrical, mechanical, or pharmacological intervention was necessary.

We never called the anaesthesiology team for assistance. All the procedures were carried out by the cardiological team as planned.

All patients generally showed a fast recovery waking up in a few minutes (generally 3–5 min to first verbal response).

Our protocol minimizes the necessary dose of propofol and consequently the risk of respiratory depression and is performed by cardiologists with experience in anaesthetic drugs.

There was no hypotension of clinical relevance or requiring therapeutic measure after the procedure.

Thrombo-embolic complications

No thrombo-embolic complications, stroke, or transient ischaemic attacks were observed in the first 24 h after the procedure.

Arrhythmic complications

Shock-related arrhythmias were uncommon and limited essentially to bradyarrhythmias occurring immediately after shock. No ventricular arrhythmia was noted. Bradycardiac phenomena were so distributed: two cases of sinus bradycardia, two junctional rhythms, and five cases of second-degree atrioventricular block. The bradyarrhythmia resolved spontaneously in the subsequent few hours in six patients, whereas three patients required a pacemaker implantation. In statistical analysis, there was not any evidence of significant correlation between developing of post-shock arrhythmia and maximal energy delivered, age, left ventricular systolic function, resting heart rate, or bundle-branch block at admission ECG. Logistic regression confirmed these results. AFL, as the main type of atrial arrhythmia (present on enrolment and confirmed on admission), and previous cardiac valvular surgery, particularly their combination, were the only variables that significantly correlated with the development of post-shock bradyarrhythmias (Table 3).

Discussion

The main finding of this retrospective study is that a general anaesthesia for outpatient elective EC can be safely handled by a cardiologist with adequate experience with anaesthetical agents in a selected population. Moreover, the association of midazolam and a very small dosage of propofol, given their synergic action, is effective and safe in inducing anaesthesia.

Nowadays, EC is usually carried out in outpatient setting as the standard of care. Like other day case procedures involving general anaesthesia, EC requires the use of short-acting anaesthetic drugs to allow fast and complete recovery of the patient before discharge that generally is planned within a few hours after the procedure.

The ideal anaesthetic agent for this purpose should be short-acting, produce a rapid loss of consciousness, prompt recovery, have very few side effects, and not or minimally affect the
Anaesthesia for electrical cardioversion

Table 3 Adverse bradyarrhythmic events ($\chi^2$)

<table>
<thead>
<tr>
<th>Event Type</th>
<th>Adverse events group (total = 9)</th>
<th>No adverse events group (total = 615)</th>
<th>P-value ($\chi^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bundle-branch block</td>
<td>2/9 (22)</td>
<td>84/615 (13.6)</td>
<td>0.88</td>
</tr>
<tr>
<td>Atrial flutter</td>
<td>6/9 (66)</td>
<td>49/615 (7.9)</td>
<td>0.0005</td>
</tr>
<tr>
<td>Valvular cardiac surgery</td>
<td>5/9 (55)</td>
<td>42/615 (6.8)</td>
<td>0.0005</td>
</tr>
<tr>
<td>Atrial flutter and valvular cardiac surgery</td>
<td>5/9 (55)</td>
<td>12/615 (1.9)</td>
<td>&lt;0.0005</td>
</tr>
</tbody>
</table>

Numbers are expressed as n (%). Comparisons have been performed with the $\chi^2$ test.

haemodynamic stability. Several drugs have been investigated in previous studies for this kind of procedure, such as diazepam,14–16 midazolam,17–19 methohexitone,18,20,21 propofol,18,20–25 thiopentone,16,17,24,25 and etomidate17,26–28 alone or in various association, comparing their effects.

Propofol is a well-known short-acting drug with good characteristics for its use during EC, allowing fast recovery, minimal haemodynamic effect, lack of myoclonic activity, and obtunds laryngeal reflexes well lowering the risk of laryngospasm.

Blood pressure may be reduced by propofol but mostly, if we consider a possible catecholamine incretion due to electrical shock, the cumulative effect of the above-mentioned mechanisms results in a minimal haemodynamic effect if a careful dose titration and slow infusion are provided.18,20,21,26

Propofol, when used as the only drug to induce anaesthesia, has a good comfortable sedative effect, but the required dose involves a not negligible incidence of apnoea.29

Apnoea and generally hypoxia due to oversedation require prompt and skilled airway management to avoid evolution towards cardiorespiratory events up until cardiac arrest. This is only one of the principal reasons why propofol, and anaesthetics in general, need to be handled by anaesthetists.

In daily practice, the coordination of the two teams, cardiologist and anaesthetist with nurse, may often be challenging and increase waiting time, increase costs, and contribute to low patient’s satisfaction. Various efforts and attempts have been made to prove feasibility of non-anaesthetists management of deep sedation or brief general anaesthesia, but there are still some concerns about the safety profile.

Benzodiazepines have been used alone in EC, but they are far from the profile of the ideal anaesthetic agent and not free of risks. Midazolam, when used as a single drug for EC, may require a larger dose with longer recovery time that may increase the risk of respiratory depression. In this case, capnography may provide a useful instrument for early recognition of respiratory depression.30,31

Another potential disadvantage of benzodiazepines, and generally more frequent in the light planes of anaesthesia, is laryngospasm due to predominance of adductor muscle tone of the vocal cords potentially leading to complete airway obstruction.

Our protocol seems to offer some advantages over the use of single anaesthetics.

Pre-medication with short-acting benzodiazepines, such as midazolam, may significantly reduce the relative dose of propofol and consequential risks. Moreover, the association of midazolam and propofol seems to produce more a synergistic rather than a merely additive effect maintaining fast recovery time.32 This mechanism may contribute to achieve the desired level of sedation with a reduction in the relative dose of the single anaesthetic.

The result is a brief general anaesthesia, easily handled by cardiologists with an adequate knowledge and experience of anaesthetic drugs.

It is very important to highlight that slow administration and careful dose titration is the recommended method of drug administration throughout a continual assessment of the level of sedation to achieve the optimal sedation progressively, avoiding or minimizing the risk of overdosage. Adequate hyperextension of the neck with the appropriate manoeuvre and assessment of patency of the airways is essential at the beginning of the procedure while achieving deep sedation.

The selection of patients is also very important. Predicting potential difficulties in airway management is imperative to avoid unnecessary risks in elective procedures.

ASA guidelines provide a complete list particularly useful to identifying patients at higher risk of developing anaesthesia-related complications.33

Another issue to raise is if flumazenil is really necessary. Reverting the effect of midazolam with flumazenil shortens the recovery time. It is important to remember that the half-life of flumazenil is shorter than midazolam, and so, after a rapid awakening, the patient runs the risk to fall asleep again.34 To avoid re-sedation, we chose to repeat the second-half dose in the case of initial re-sedation. Continual clinical observation for some hours, throughout recovery after the procedure is very important even after the administration of flumazenil. Rapid reversion of anaesthesia should not encourage the use of anaesthetic drugs by inexperienced personnel.

Another interesting issue regards the best method to evaluate recovery from anaesthesia. Various cognitive and psychomotor tests have been described in the literature each of one with advantages and disadvantages. However, it is unclear which is the gold standard test to evaluate discharging in outpatient procedures involving general anaesthesia. The digit symbol substitution test,35 which evaluates the perceptual processing, the Trieger dot test,36 which involves sensory processes, the perceptual speed test,37 the Steward post-anaesthetic recovery score,38 or the Aldrete score39 are some of the most used tests for this purpose.

Each of these tests has its advantages and limits, generally intrinsic to the type of test and its ability to investigate predominantly a cognitive or sensorial or psychomotorial sphere.

We did not perform any sophisticated test to evaluate recovery, but we did not want to compare any test in our retrospective evaluation. The study was not designed for this purpose.

The recovery phase, from return to the baseline of vital parameter to the total recuperation of consciousness, usually taking a few minutes, was continually monitored by the personnel. During this period, an ECG was carried out to assess sinus
rhythm, a new blood pressure check and continual ECG monitoring to verify eventual arrhythmic phenomena were performed.

Subsequent observation of the patient, after a complete recuperation of consciousness, in bed, lasted not less than from 2 up to 4 h after the procedure; in this period, familiars were involved in an active role being told to keep on talking to the patient and to refer any kind of problem. Before discharge, the personnel again evaluated the patient and assessed complete recuperation and deambulatory capability. Patients were always told not to drive or do complex activity and to have a light diet in the evening.

Criteria used to evaluate total recovery are substantially clinical, but on the other hand, the complex cognitive and psychomotor tests mentioned above have some intrinsic limits.

To our knowledge, there is no scientific comparison of this common practice towards sophisticated tests in the literature. However, the total absence of anaesthesia-related complications in a large population may contribute to define this common practice as reliable and ‘good’.

We have to consider that, even if the examined population is large, the study may be underpowered to claim the absolute safety of the protocol if we consider a mortality rate in general anaesthesia less than 1:185 000. However, there is more than one factor influencing the success of a procedure. Paddles position, or duration of AF, may also be relevant. Anyhow the high success rate of the procedure, performed according to the high procedural standards and with biphasic cardioverter, gives us a very low level of failure, that appears difficult to study and to improve.

Conclusions
Our study shows that an exclusively cardiological management of EC, in an outpatient setting, with anaesthetist on hand, appears to be safe not only in a low-risk population but also in a population that resembles clinical features of the majority of patients. The administration of a combination of midazolam and propofol resulted safe and effective, and no anaesthesia-related side effects were detected.

This issue is particularly present, nowadays when economic savings are required, since not using anaesthesiologists would be an effective cost-saving measure for the healthcare system.

Our report could lead to further means of future evaluations of this particular protocol in order to use it in clinical practice with the necessary safety.

Finally, our data confirm that bradyarrhythmic complications are uncommon and may be prevented or better managed by identification of risk factors for their development. Surface ECG analysis and clinical history may allow the operator to recognize patients at higher risk of post-shock bradyarrhythmias, avoiding unexpected potentially life-threatening situations and leading to a better management.

Study limitations
This is a retrospective study with inherent (design-related) limitations common to every retrospective analysis.

Even if the analysed population in our study is very large, considering the issue, the study may be underpowered to claim the absolute safety of this protocol.

We do not have enough information about the real AF recurrences after shock but this was unnecessary for our aims.

Conflict of interest: none declared.

References