Scientific Works. Series C. Veterinary Medicine. Vol. LXVI (1), 2020
ISSN 2065-1295; ISSN 2343-9394 (CD-ROM); ISSN 2067-3663 (Online); ISSN-L 2065-1295

EXPERIMENTAL TESTING OF A DEFIBRILLATION PROTOCOL ON PIGS

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Abstract

Testing of a defibrillation protocol is necessary in order to add additional security to the monitoring and support protocols during the experimental procedures developed on pigs. Pigs are placed under general anaesthesia and continuous monitoring (capnography, pulse-oximetry, blood pressure measurement). The experimental testing consists in creating the conditions needed for the heart to enter the states of ventricular tachycardia (VT) and ventricular fibrillation (VF) followed by the pre-chosen defibrillation protocol. By every defibrillation shock added, the normal sinus rhythm was sustained for a longer period, in relation with the number of shocks applied. Survivability could not be sustained only with defibrillation, the use of CPR and cardio tonic medication being recommended.

Key words*: defibrillation, protocol, pig.*

INTRODUCTION

The aim of this experimental study is to test the efficiency of defibrillation protocols in pigs, used during experimental procedures, in order to develop further cardio pulmonary resuscitation guidelines.

MATERIALS AND METHODS

All 5 subjects were selected respecting the same principles for housing, feeding, anaesthesia and surgical principles (Mitrănescu, 2008), in accordance with the Directive 2010/63/EU on the protection of animals used for scientific purposes (E.C., 2010) and manipulated in regard to ensure a high level of animal welfare as a moral duty of human being regarding the animals (Mitranescu, 2009) and approved by the Ethic Commission of the Faculty of Veterinary Medicine of Bucharest, as part of a bigger research project regarding the use of pigs for experimental procedures.

Subject selection- five female domestic pigs (25-35 kg) were used for this study. Animals were acclimatised in the same conditions for 48h before the experiment was conducted and were fasted overnight but had access to water. For experimental surgery, there is a need for anaesthesia protocols depending on the complexity of the procedures. Subjects were evaluated trough a complete pre anaesthetic examination (clinical examination, body condition, weighing) 24 hours before the procedure and assigned to an anaesthetic risk group- ASA adapted for veterinary medicine (Table 1).

Table 1. **ASA risk classification** adapted for veterinary medicine (*American Society of Anaesthesiologists*) and subjects distribution

ASA 1	A normal healthy patient, with no organic disease	All 5 subjects
ASA 2	A patient with mild systemic disease	
ASA 3	A patient with severe systemic disease that limits activity but it`s not incapacitating	
ASA 4	A patient with sever systemic disease that is a constant threat to life	
ASA 5	A moribund patient who is not expected to survive 24 hours without intervention	

Pigs were anaesthetized and surgical prepared for an experimental laparoscopy surgery. Anaesthetic protocol- premedication by intramuscular injection with Xylazine 2 mg/kg and Ketamine 20 mg/kg, followed after 10 minutes by induction- with Propofol 5 mg/kg and maintenance with Isoflurane and oxygen for adequate anaesthetic depth (Bîrtoiu, 2009). The animals were intubated with 5.0 to 6.0 size tracheal tube.

All 5 subjects were monitored with: electrocardiography (ECG) (Figure 1) using standard bipolar limb leads with self-adhesive electrodes, capnography, pulse-oximetry (SpO2) with sensors placed on the tongue of the pigs and non-invasive blood pressure, by pressure cuff placed on one of the front limbs.
A continuous infusion of 10 ml/h of NaCl (0.9%) was infused via a peripheral catheter placed on the lateral auricular vein (Costea, 2019). Respiration was sustained by ventilation delivered by volume-controlled ventilator with a tidal volume of 10 ml/kg (IPPV), respiratory rate 10 breaths/min.).
The defibrillator used for this study was a human paediatric device (Biphasic Multifunctional Defibrillator/Monitor from South Korean Manufacturers Mediana), capable of delivering shocks from a large interval (1 J to 360 J) (Figure 1).
The defibrillator is used to apply an electric current to the heart, also known as a shock. Shocks are applied with pads that were cleaned before the experiment and lubed with gel (Savage, 2013).
The pads are applied on the chest of the animal, one to the sternum and one on the fifth to seventh intercostal space, on the left side, corresponding to the heart apex.

Figure 1. The D500 defibrillator from South Korean Manufacturers Mediana used for the experiment

The experiment began with a laparotomy procedure, performed via the medial abdominal line from the sternum to the umbilical scar, as part of a bigger research experimental procedure.
Pigs were under anaesthesia already for a period of 3 to 4 hours, for experimental laparoscopy procedure, when diaphragm was perforated, by a vertical incision of 10 cm, in the medial plan, from the xiphoid process, using a surgical scalpel to simulate a trauma.
The defibrillation protocol chosen for the procedure was composed of three shocks with different intensities: first shock-2 J/kg, second shock- 3.5 J/kg, third shock-5 J/kg.

RESULTS AND DISCUSSIONS

All 5 subjects were healthy, with no organic diseases and included in ASA risk group 1 and received the same anaesthetic protocol during the experimental laparoscopic surgical procedure.
We measured the duration (seconds) from the moment when the diaphragm was punctured (T = O) to the instalment of ventricular tachycardia (VT) and after until the confirmation of ventricular fibrillation (VF) through ECG.
Ten to fifteen seconds (mean of 13 seconds) after the puncturing was performed, pigs hearts entered a state of ventricular tachycardia (VT) followed in maximum 120 seconds (mean of 103 seconds) by ventricular fibrillation (VF) and confirmed by the monitor EKG in lead II (Figure 2).

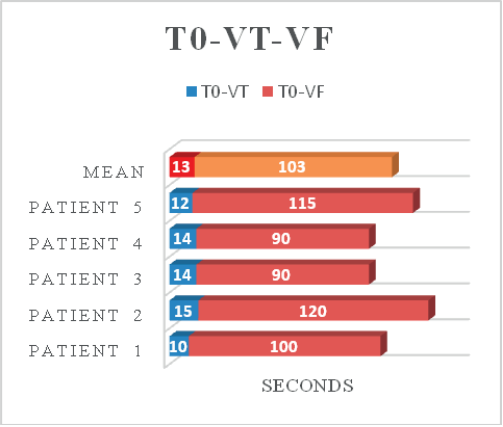

Figure 2. Mean time after diaphragmatic trauma (T = 0) to enter in ventricular tachycardia (VT) and time for each patient to enter ventricular fibrillation (VF)

Figure 3- Biphasic manual defibrillation with D500 defibrillator Mediana

Defibrillation protocol was applied after the VF was confirmed, starting with the first shock by biphasic manual defibrillation - with paddles (Figure 3). The first shock (2 J/kg) was applied and the response was a brief 2-6 seconds of sinus rhythm, in all 5 pigs, and after that reverting to ventricular fibrillation.

The second shock (3.5 J/kg) was applied and the response was a sinus rhythm sustained by itself for 270 to 360 seconds in three out of the five pigs (3/5). In the other two pigs (2/5) the response to the second shock determined a response similar to the first shock-5 seconds.

The third shock (5 J/kg) was applied and the response was a sinus rhythm sustained for by itself for 340 to 365 seconds in two out of the five pigs, followed by asystole. For pig number 5, after the third shock was performed, a brief (2-3 sec.) sinus rhythm was installed followed by a quick (1-2 sec.) instalment of VF. For this pig we decide to give a 4th shock, with the same intensity (5 J/kg), after the instalment of VF and the result was self-sustained sinus rhythm for 370 seconds (Table 2, Figure 4). Two pigs did not respond to the third shock and were removed from the protocol. By every defibrillation, shock added to the protocol the normal sinus rhythm was sustained for a longer period of time (Figure 5) for the entire group, but in different moments, respectively after a variable number of defibrillation shocks applied. After the normal cardiac rhythm was kept on its own, the heart went into fatigue that leads to asystole state and heart failure. No vasopressors and anticholinergic drugs were used during the resuscitation protocols and no chest compressions were to be given between shocks.

Table 2. Duration of sinus rhythm response, after 1st, 2nd, 3rd and 4th defibrillator shocks, for each of the 5 animals

Patient	1	2	3	4	5
1st shock 2 J/kg Sinus rhythm response	2 sec.	3 sec.	5 sec.	2 sec.	6 sec.
2nd shock 3.5 J/kg Sinus rhythm response	270 sec.	5 sec.	360 sec.	5 sec.	355 sec.
3rd shock 5 J/kg Sinus rhythm response	No response	340 sec.	No response	365 sec.	2 Sec.
4th shock 5 J/kg Sinus rhythm response	-	-	-	-	370 sec.

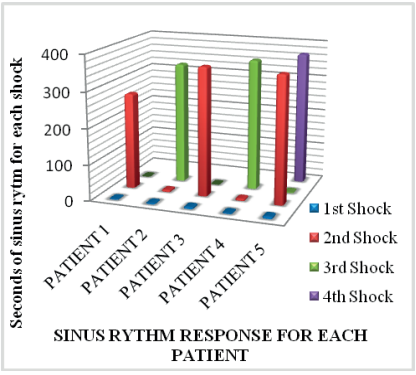

Figure 4. Evaluation of shock responses

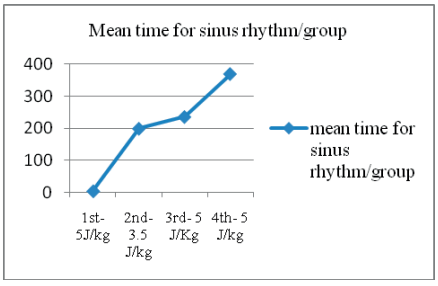

Figure 5. Mean time for sinus rhythm/group after each defibrillation shock

CONCLUSIONS

Traumatic diaphragmatic perforation induced ventricular tachycardia (VT) followed by ventricular fibrillation (VF) for pigs under anaesthesia for a period of 3 to 4 hours, for experimental laparoscopy procedures

Defibrillation protocols used on pigs have a good success rate at higher voltage since shocks of low voltage (1st shock-2 J/kg) did not produce reliable responses.

In this study, the results were promising with 3.5 to 5 J/kg shocks, respectively 2nd and 3rd shock applied.

Using a shock at higher intensity right after the first shock would increase the chances for a normal sinus rhythm instalment.

By every defibrillation, shock added to the protocol the normal sinus rhythm was sustained for a longer period of time for, in relation with the number of defibrillation shocks applied.

Long-term survivability cannot be obtained only with defibrillation, the use of CPR and cardio tonic medication should absolutely be used in cases like these.

These results open new possible hypothesis for further researches concerning the association between resuscitation medication and defibrillation protocols.

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