REFIBRILLATION: RATE OF REFIBRILLATION AND TIME BETWEEN THE DEFIBRILLATION AND THE REFIBRILLATION

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Clinical evidence shows that patients in cardiac arrest who are defibrillated by an Automatic or Semiautomatic External Defibrillators often experience a recurrence of ventricular fibrillation prior to arrival of advanced life support. We studied the probability for refibrillation and the duration of the interval between the defibrillation and the refibrillation. The refibrillation rates after shocks with 90J, 130J and 180J were 70.3 %, 73.4% and 86.5 % respectively. The refibrillation time had maximal number of observations between 30s and 40s for shocks with 90J and 130J, and between 5s and 10s for shocks with 180J.

Keywords: fibrillation, defibrillation shock, refibrillation time

1. INTRODUCTION

Ventricular fibrillation (VF) is a dangerous cardiac arrhythmia, which leads to inevitable death if no defibrillation shock is applied on the subject within several minutes. Clinical evidence shows that patients in cardiac arrest who are defibrillated by an Automatic or Semiautomatic External Defibrillators (AED or SAED) often experience a recurrence of VF prior to arrival of advanced life support [1]. This is not surprising, as the conditions that led to the VF may still be present. Patients can re-fibrillate several times, which leads to application of multiple shocks [2, 3, 4]. Stults and Brown [1] analyzed 271 cases of VF. They reported for 111 patients, which initially converted to organized rhythms, 19 (17%) of which refibrillated afterwards. Hess and White [5] studied the performance of AEDs, which work with non-escalating 150J biphasic truncated exponential waveform shocks. Among 67 patients with initial shock success, 30 (45%) survived to neurologically intact discharge. Twenty-nine patients (43%) regained spontaneous circulation with shocks only and 25 of 29 (86%) survived. VF recurred in 35 of the 67 patients (52%) while being cared for by police or firefighters.

The aim of this study was to determine the probability for refibrillation and the duration of the interval between the defibrillation and the refibrillation for different energies and larger set of defibrillation shocks.

2. METHOD

2.1 ECG signals

ECG records with defibrillation shocks were taken from a database containing more than 1200 out-of-hospital fibrillation cases, which were collected during interventions with 70 SAEDs. The ECGs were stored in PCMCIA cards of automatic external defibrillators used by fire brigades in the region of Nancy, France between

April 2001 and January 2004 and later organized in a PC database. Unfortunately, the interventions' delays are unknown for this population. The defibrillation pulse, which was used in these SAEDs was a US patented chopped biphasic waveform with an impedance compensation [6]. Two types of shock sequences were used: (i) 90J/130J/180J (in 119 operations) and (ii) 130J/130J/180J (in 129 operations). The groups of 3 shocks were separated by 1 min CPR.

2.2 Software utility

Software for visual shock success estimation was developed under MATLAB environment. The general view of this software utility is shown in figure 1.

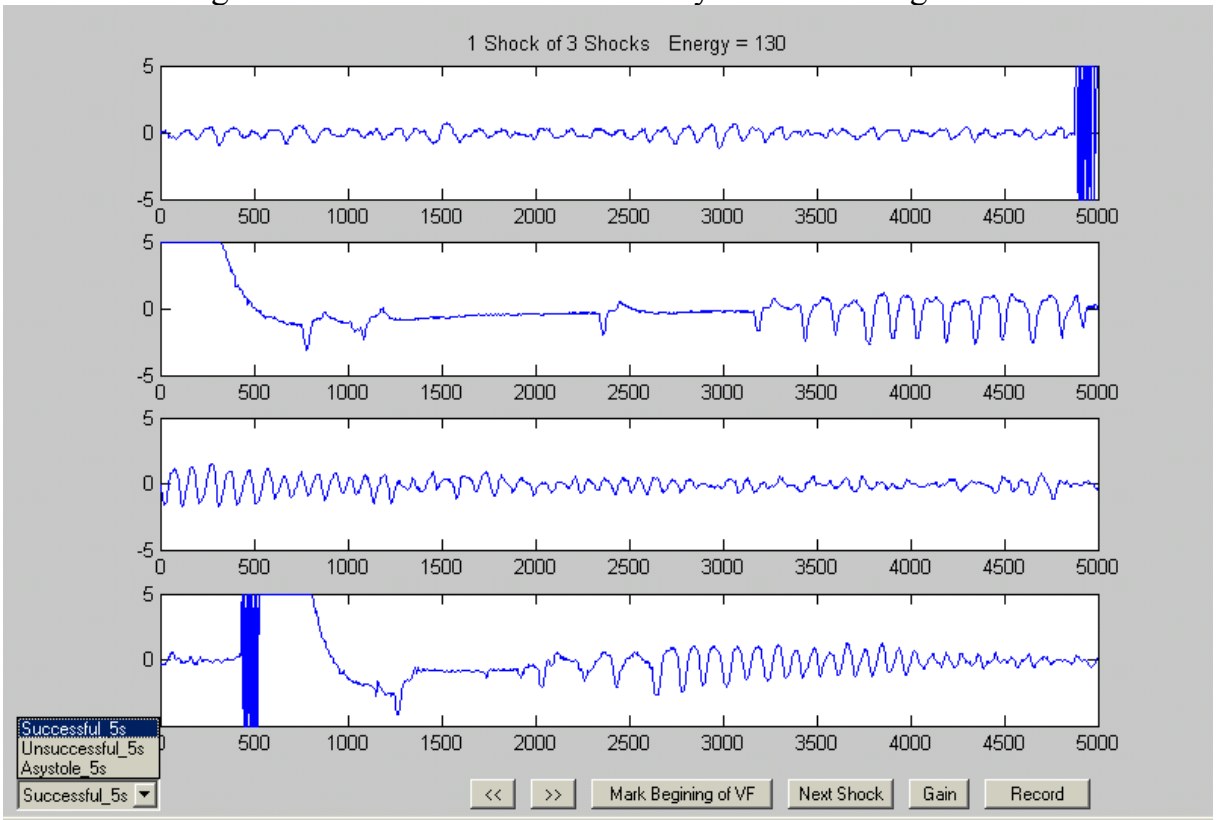

Figure 1 General view of the software utility for shock success estimation

This software has the following features:

- Four ECG traces – one 10s ECG segment before the shock and three 10s ECG segments (30s) after the shock for shock success estimation within 5s.
- Three 'popup menus' for selection of the shock effect:
  - Successful - the delivered shock terminated the ventricular fibrillation and the result was non-shockable rhythm, which contains cardiac complexes;
  - Unsuccessful - the delivered shock did not terminate the ventricular fibrillation;
  - Asystole - the delivered shock terminated the ventricular fibrillation and the result was asystole;
- Buttons for Forward (>>) and Backward (<<) movement throughout the ECG recording.

- Button for marking the beginning of ventricular fibrillation, which appears after a successful shock (the VF was terminated and than refibrillation appears).
- Button for next shock selection.
- Button for gain control.
- Button for recording the data in file.

The number and energy of the current shock and the count of all shocks in the selected file are shown as a title of the figure.

2.3 Statistical analysis

The statistical analysis of the recorded data was performed using the software package Statistica.

3. RESULTS

A retrospective study, which consisted in analysing the probability for refibrillation and the refibrillation time during interventions with 70 SAEDs was done. The outcome of the defibrillation was labeled either as successful (when the shock terminated the VF) or as not successful (when the shock did not terminate the VF) at 5 seconds after the shock.

A statistical analysis of the refibrillation rate and the time between a successful defibrillation and the refibrillation (where present) was performed. A total of 631 successful shocks were analysed – 189 shocks with 90J, 307 shocks with 130J and 135 shocks with 180J.

The mean value, minimal value, maximal value and the standard deviation of the refibrillation time are given in table 1. The successful rate of all shocks and the refibrillation rate were assessed, and the results are given in table 2. The median values of the refibrillation time, 25% - 75% range around the median value, non-outlier range, outliers and extremes for all defibrillation energies are presented in figure 2 and the histograms of the refibrillation time for shocks with energies 90 J, 130 J and 180 J are shown in figures 3, 4 and 5 respectively.

Energy [J]	***Total number of refibrillations***	***Refibrillations between 5s and 180s***	***Mean [s]***	***St. Dev. [s]***	***Min [s]***	***Max [s]***
90	189	161	42.6	30.6	5	164
130	307	275	45.7	37.3	5	166
180	135	125	27.8	28.5	5	152

Table 1 Refibrillation time – total number of refibrillations; refibrillations between 5s and 180 s; mean value, standard deviation, minimum and maximum of the refibrillations between 5s and 180 s.

Energy [J]	***Number of delivered shocks***	***Successful shocks, (Ratio between the successful and the delivered shocks)***	***Number of refibrillations after a successful shock, (Ratio between the refibrillations and the successful shocks)***
90	374	269 (***71.9%***)	189 (***70.3%***)
130	580	418 (***72.1%***)	307 (***73.4%***)
180	294	156 (***53.1%***)	135 (***86.5%***)

Table 2 Successful shocks, ratio between the successful and the delivered shocks [%], number of refibrillations after a successful shock, ratio between the refibrillations and the successful shocks [%].

The refibrillation rates after shocks with 90J, 130J and 180J were 70.3 %, 73.4% and 86.5 % respectively. The refibrillation time had maximal number of observations between 30s and 40s for shocks with 90J and 130J, and between 5s and 10s for shocks with 180J. The histogram of the refibrillation time for 180J had significant components up to 60s, while the histograms for 90J and 130J had significant components even above 100s. The mean value of the refibrillation time for shocks with 180J was significantly lower than the mean values for shocks with 90J and 130J.

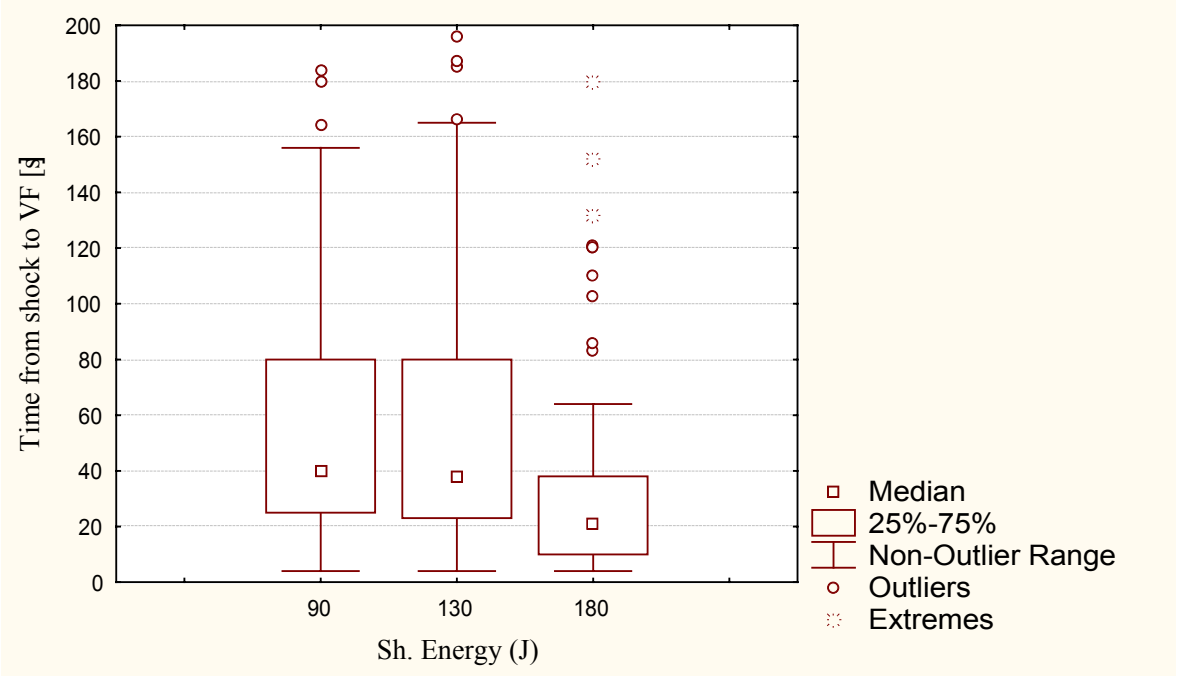

Figure 2. Median value of the time to refibrillation, 25% - 75% range around the median value, non-outlier range, outliers and extremes for all defibrillation energies.

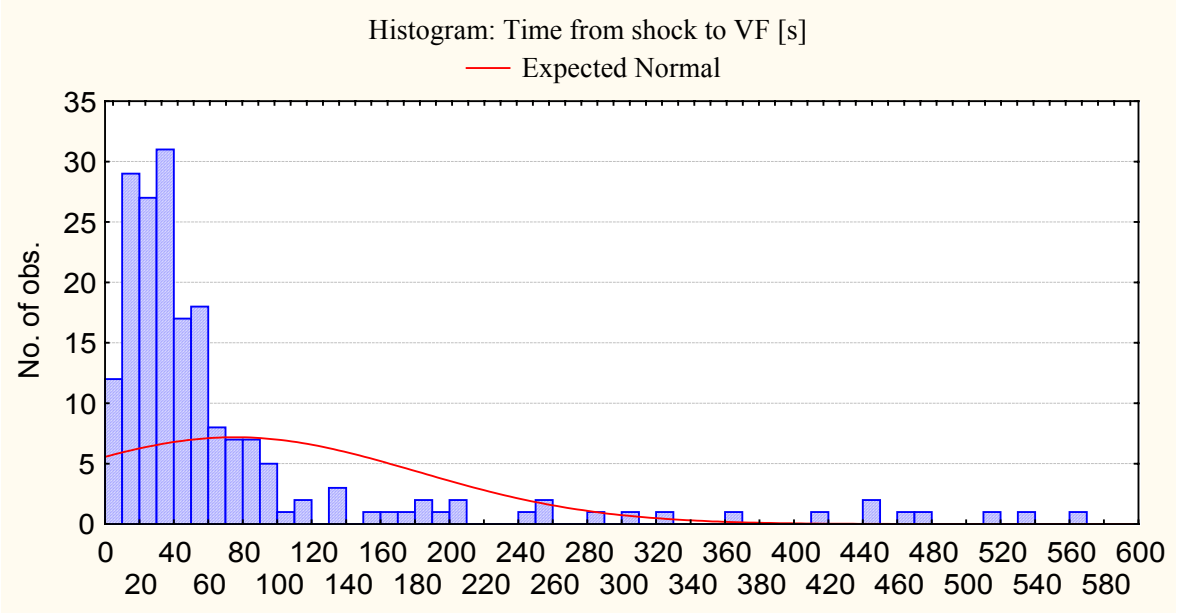

Figure 3. Histogram of the time of refibrillation (from 0 to 600 s) for shocks with energy 90 J.

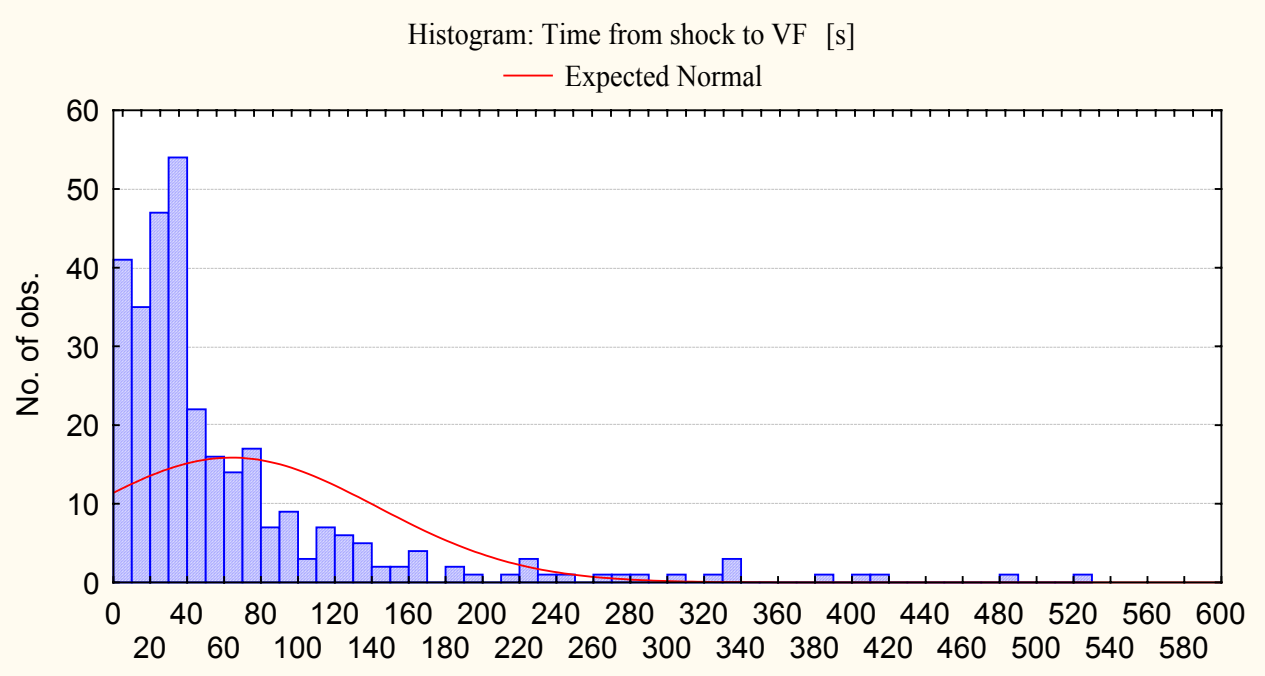

Figure 4. Histogram of the time of refibrillation (from 0 to 600 s) for shocks with energy 130 J.

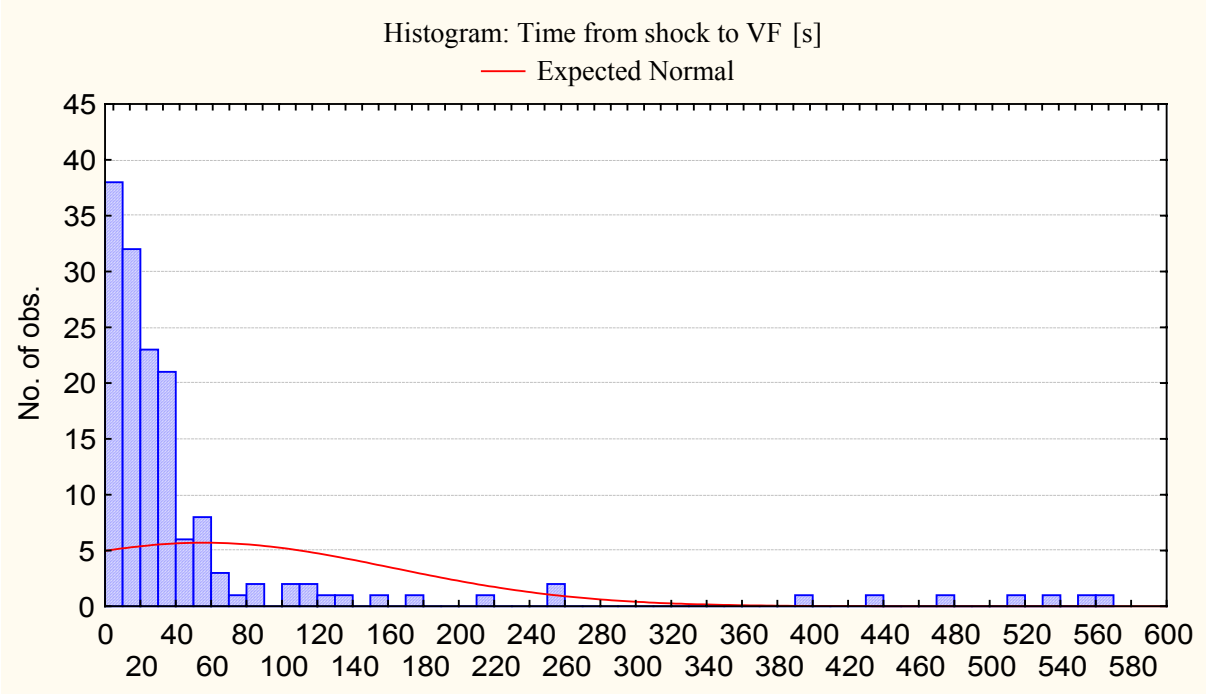

Figure 5. Histogram of the time of refibrillation (from 0 to 600 s) for shocks with energy 180 J.

4. DISCUSSION AND CONCLUSION

A comparison of our results for the refibrillation rate with the results obtained by the cited authors is proposed in table 3. However, this comparison is limited, since Stults and Brown analyzed patient status but not the result of individual shocks, and Hess and White studied only successful initial shocks (*). This fact could be

considered as a possible reason for the evident great difference between the results of the compared works.

Authors	***Shock Energy***	***Analysed dataset***	***Successful defibrillations***	***Refibrillations***
Stults and Brown	-	271 cases	111 (***41%***)	19 (***17%***)
Hess and White	150 J	67 cases *	67	35 (***52 %***)
Jekova	90 J	374 cases	269 (***71.9%***)	189 (***70.3%***)
	130 J	580 cases	418 (***72.1%***)	307 (***73.4%***)
	180 J	294 cases	156 (***53.1%***)	135 (***86.5%***)

Table 3. A comparison of the results for refibrillation rate in three studies

It is obvious that the low refibrillation rate in the study of Stults and Brown is balanced by low rate of the successful defibrillations. The work of Hess and White shows 52 % probability for refibrillation but there is no information about the success of defibrillation.

Taking into account the results obtained in this study, it can be speculated that the patient is more susceptible to refibrillation after a shock with 180J. Unfortunately, we have no information neither about the time delay between the beginning of the fibrillation and the defibrillation, nor about the conditions that led to the VF. Therefore, we cannot exclude the possibility this high rate of refibrillations after shocks with 180J to be due to some heart diseases, which impede the defibrillation with lower energies and lead to refibrillation after a shock with 180J.

The maximal number of observations of the refibrillation time between 30s and 40s for shocks with 90J and 130J, and between 5s and 10s for shocks with 180J, as well as, the fact that the refibrillation time had significant components up to 60s for 180J and above 100s for 90J and 130J, shows that vigilance for recurrent VF is essential to ensure the survival of patients who are in the care of first responders, even after initial restoration of spontaneous rhythms by means of defibrillation shocks.

5. REFERENCES

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