ORIGINAL ARTICLE

Stability of succinylcholine solutions stored at room temperature studied by nuclear magnetic resonance spectroscopy

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Emerg Med J 2007;24:168–169. doi: 10.1136/emj.2006.041053

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Accepted 6 October 2006

The effect of storage temperature on the stability of two succinylcholine chloride solutions (20 and 50 mg/ml) was evaluated. Molecular composition was analysed using nuclear magnetic resonance spectroscopy. At room temperature, the degradation rate constant was 1.2%/month for the 20 mg/ml solution and 2.1%/month for the 50 mg/ml solution. The corresponding monthly degradation rates for the two solutions were 0.18% and 0.30% when stored at 4°C, and 5.4% and 8.1% when stored at 37°C. If a 10% loss of potency is considered acceptable, then the 20 and 50 mg/ml succinylcholine solutions can be stored in emergency resuscitation carts at room temperature for 8.3 and 4.8 months, respectively.

Commercially available solutions of succinylcholine chloride should be stored at 2–8°C to prevent loss of potency as recommended by the manufacturers. The stepwise degradation initially results in the formation of an inactive monoester (succinylmonocholine), which subsequently undergoes much slower hydrolysis to yield choline and succinic acid.^{1,2}

However, because of the need for immediate availability, succinylcholine solutions are often kept at room temperature in emergency resuscitation carts.

Accordingly, this study was designed to determine the effect of storage temperature conditions on the stability of succinylcholine solutions that are commonly used in the emergency setting.

METHODS

Two commercially available succinylcholine chloride solutions (20 mg/ml, Organon, Roseland, NJ, USA, and 50 mg/ml, Pharmacia & Upjohn, Bridgewater, NJ, USA) were studied. Ampoules of each solution were stored under three conditions:

in emergency resuscitation carts at room temperature in the intensive care unit (RT group); in a temperature chamber at a constant 37°C (37°C group) and in a refrigerator at a constant 4°C temperature (4°C group). All ampoules were kept in the same light conditions. Molecular composition was analysed in five samples for each determination using nuclear magnetic resonance spectroscopy (NMR 500 MHz, Varian Unity Inova Spectrometer, Palo Alto, CA, USA). The signal intensities were determined by integrating the area under the peak.

To determine the degradation ratio, the intensity of the multiplet at 3.5 ppm, corresponding to free choline, was compared with that at 3.7 ppm, corresponding to succinylcholine and succinylmonocholine.

RESULTS

Initial pH values of the 20 and 50 mg/ml succinylcholine samples were (mean (SD)) 3.52 (0.03) and 3.1 (0.03), respectively. Figure 1A and B shows the degradation of succinylcholine injection as a function of time when stored in emergency resuscitation carts (RT group) compared with the

Table 1 Loss of potency of succinylcholine chloride 20 mg/ml and 50 mg/ml injection solutions at 37°C, room temperature and 4°C

Storage temperature	Parameter	Succinylcholine, 20 mg/ml	Succinylcholine, 50 mg/ml
37°C	Degradation rate constant	5.4%/month	8.1%/month
	Slope	0.0018/day	0.0027/day
	Correlation coefficient (r^2) of concentration versus time	0.9964	0.9962
Room temperature (21–25°C)	Degradation rate constant	1.2%/month	2.1%/month
	Slope	0.0004/day	0.0007/day
	Correlation coefficient (r^2) of concentration versus time	0.9996	0.9999
4°C	Degradation rate constant	0.18%/month	0.30%/month
	Slope	0.00006/day	0.0001/day
	Correlation coefficient (r^2) of concentration versus time	0.7962	0.7795

Figure 1 Time-degradation of succinylcholine chloride aqueous solutions at room temperature (RT), 37°C and 4°C: (A) 50 mg/ml concentration; (B) 20 mg/ml concentration.

37°C and 4°C groups. The linear relationship between the amount decomposed and time indicates that the reaction follows apparent zero-order kinetics at all temperatures ($r^2 > 0.99$ for the 37°C and RT groups). Table 1 shows the degradation rate constants and the correlation coefficients.

If a 10% loss of potency is considered acceptable, then the 20 and the 50 mg/ml succinylcholine solutions can be stored in emergency resuscitation carts at room temperature for approximately 8.3 and 4.8 months, respectively.

DISCUSSION

The results of our study show that the 20 and the 50 mg/ml succinylcholine solutions can be stored in emergency resuscitation carts without refrigeration for about 8 and 5 months, respectively, without considerable loss of potency. A literature review shows that the stability of succinylcholine at room temperature is highly variable between studies and between manufacturers—for example, Squibb indicated 6 months stability at room temperature for the 20 and 50 mg/ml solutions, and 3 months stability for the 100 mg/ml solution.³ Glaxo Wellcome indicated that the 20 mg/ml solution is stable for up to 14 days at room temperature.⁴

The degradation ratio of succinylcholine is closely dependent on initial pH, as shown by Boehm *et al*,⁵ such that an increased pH value is associated with a decreased degradation rate. The two solutions used in this study had different initial pH values, and we found, in accordance with previous authors, that the rate of degradation of the 20 mg/ml solution (pH 3.52 (0.03)) was slower than that of the 50 mg/ml solution (pH 3.1 (0.03)).

This fact explains the apparent zero-order degradation kinetics of succinylcholine. The hydrolysis of succinylcholine is catalysed by hydrogen ions. During the degradation of succinylcholine, production of succinic acid decreases the pH value and speeds up the reaction. Finally, the rate of hydrolysis is maintained constant because of the slowing down effect of the decreased succinylcholine concentration. On the other hand, exposure to light affects the stability of succinylcholine chloride injections only slightly.²

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Competing interests: None declared.

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