ORIGINAL ARTICLE

Educational psychology in medical learning: a randomised controlled trial of two aide memoires for the recall of causes of electromechanical dissociation

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Objectives: Although mnemonics are commonly used in medical education there are few data on their effectiveness. A RCT was undertaken to test the hypothesis that a new aide memoire, "EMD-aide", would be superior to the conventional "4Hs+4Ts" mnemonic in facilitating recall of causes of electromechanical dissociation (EMD) among house officers.

Method: "EMD-aide", organises causes of EMD by frequency of occurrence and ease of reversibility: four groups organised by shape, colour, position, numbering, clockwise sequence, and use of arrows. Eight hospitals were randomised in a controlled trial and 149 house officers were then recruited by telephone. Baseline ability to recall causes of EMD was recorded at one minute and overall. House officers were then sent a copy of either "4Hs+4Ts" or "EMD-aide" according to randomisation group. Recall ability was retested at one month.

Results: 68 of 80 and 51 of 69 house officers completed the study in the "4Hs+4Ts" and "EMD-aide" groups respectively (NS) with similar baseline recall. After intervention median number of recalled causes was greater in the "EMD-aide" group, eight compared with seven at one minute ($p=0.034$) and eight compared with seven overall, $p=0.067$. Recall of all eight causes was more common in "EMD-aide" group, 54% compared with 35%, $p=0.054$, and these house officers spent longer examining their aide memoire, $p<0.001$.

Conclusions: "EMD-aide" may be superior to "4Hs+4Ts" in facilitating the recall of the causes of electromechanical dissociation. Educational psychology of medical learning and the use of aide memoires in general are worthy of further study.

There are eight, non-myocardial, potentially reversible causes of myocardial dysfunction and electromechanical dissociation (EMD) or pulseless electrical activity (PEA). In 1997, the Resuscitation Council suggested grouping these causes into those beginning with H and those beginning with T, the "4Hs and 4Ts" aide memoire,¹ (box), to help facilitate recall. "4Hs and 4Ts" makes no attempt to rank or group the causes in order of frequency of occurrence and ease of treatment or reversibility and the effectiveness of alliteration² and the "4Hs and 4Ts" aide memoire has never been tested. We modified an alternative aide memoire,³ "EMD-aide" (fig 1), which attempts to emphasise the commonest^{4–10} and most easily reversible causes—that is, hypoxia and hypovolaemia—relegating the less common causes (where effective treatment takes longer) to the bottom of the list (appendix).

We hypothesised that "EMD-aide" would be more effective than "4Hs and 4Ts" in facilitating learning and recall of the causes of EMD. We conducted a randomised controlled trial of the use of two aide memoires among pre-registration house officers (HOs).

METHOD

We obtained approval from the local clinical tutors from the following eight centres to conduct this study: Bournemouth, Brighton, Chelmsford, Frenchay Hospital, Poole, Portsmouth, Southampton, and Southmead Hospital. The research ethics committee considered formal approval was not required and the other centres accepted this. We randomised centres using a computer generated random sequence generator and subsequently recruited pre-registration house officers from those centres. Randomisation was by centre because we believed that, because of the close community in which HOs

live and work, it would be difficult to conduct a study randomising HOs, without HOs from each group becoming aware of the existence of the other aide memoire and hence introducing bias. One hundred and forty nine medical and surgical HOs were contacted by telephone and asked to participate in the study.

HOs were asked to recall the causes of EMD. The number and sequence of recall within (a) one minute and (b) overall, were recorded as baseline scores. HOs were then sent an aide memoire by post, either "4Hs and 4Ts" or "EMD-aide", according to their randomisation group. They were asked not to discuss the aide memoire with anyone until after completion of the study. Four weeks later the number and sequence of recall was again recorded at one minute and overall. They were also asked to estimate the time they had spent examining the aide memoire.

Sample size of 50 subjects in each group was calculated by a power analysis using an effect of one increment increase in recall, α error of 0.05, power of 80%. Statistical analysis used χ^2 and Mann-Whitney U tests. Figure 2 summarises the study design.

RESULTS

Of 149 HOs, 119 completed both baseline and post-intervention parts of the study with similar drop out rates in each arm, 12 of 80 (15%) and 18 of 69 (26%), $\chi^2 = 2.83$, $p = 0.92$. At baseline the median number of correctly recalled causes of

Abbreviations: EMD, electromechanical dissociation; PEA, pulseless electrical activity

Figure 1 EMD-aide: causes of electromechanical dissociation. Please see the journal web site (<http://www.emjonline.com/supplemental>) to view the figure in colour.

Figure 2 Study design.

EMD by HOs in the “4Hs and 4Ts” and “EMD-aide” groups was 5 and 5 respectively at one minute and 5 and 6 overall (table 1).

After the “intervention” of sending the HOs one of the aide memoires there was a clear increase in the number of correct response in each group at each time point. The “4Hs and 4Ts” group median scores rose from 5 to 7 at one minute and from 5 to 7 overall. The “EMD-aide” group median scores rose from 5 to 8 at one minute and from 6 to 8 overall. These represent rises in the overall total correct scores from 67.8% to 87.7% and from 66.6% to 91.5% respectively. The difference in the median number of items recalled was significant at one minute ($U = 1363.5$, $p = 0.034$), but not overall ($U = 1416.5$, $p = 0.068$). In the “4Hs+4Ts” group 24 of 68 HOs (35%) correctly identified all eight possible causes, compared with 27 of 51 (53%) in the EMD-aide group, table 2, ($\chi^2 = 3.71$, $p = 0.054$). The “EMD-aide” group spent significantly longer than the “4Hs and 4Ts” group examining the aide memoire, $p = 0.0001$ (table 1). Table 3 gives the proportions of HOs recalling each cause of EMD in the two groups at each time point.

DISCUSSION

Memory entails encoding information (placing information into memory effectively) and recall entails decoding (retrieval and understanding). Memory works best when it is

organised¹¹; mechanisms facilitating meaning and understanding promote learning. Devices that organise data help memorisation or accretion (adding new data to the memory banks of the mind). In addition they also assist fitting new data to old information (restructuring) and promote fine tuning, allowing data to be adapted to novel situations.

Mnemonics have been defined as devices that promote efficient memorisation and easy access to memory stores because of their novelty and familiarity,¹² or more simply as “memory tricks”.¹³ Mnemonics reputedly improve acquisition of data and recall,¹⁴ make learning easier, increasing

“4Hs and 4Ts”, aide memoire for causes of electromechanical dissociation

“4Hs + 4Ts aid”

Hypoxia
Hypovolaemia
Hyper/hypokalaemia and metabolic disorders
Hypothermia
Tension pneumothorax
Tamponade
Toxic/therapeutic substances
Thromboembolic/mechanical obstruction

Table 1 Comparison of number of correctly recalled responses, change in recall, and time spent examining aide memoires

Comparison of number of correct responses						Mann-Whitney test
		Group	Number	median	Interquartile range	p Value
Baseline:	1 min	4Hs4Ts	68	5	4–6	0.92
		EMD	51	5	4–6	
	Overall	4Hs4Ts	68	5	5–6.3	0.96
		EMD	51	6	5–6.5	
Study:	1 min	4Hs4Ts	68	7	6–8	0.034
		EMD	51	8	7–8	
	Overall	4Hs4Ts	68	7	6.8–8	0.067
		EMD	51	8	7–8	
Comparison of reported time spent looking at aide memoires (min)						0.0001
		4Hs4Ts	65	1	0.5– 2	
		EMD	49	4	2–5	

Table 2 Total number of HOs obtaining maximum eight correct causes of EMD at each time point

	4Hs4Ts	EMD	All HOs	χ^2
	n = 68	n = 51	n = 119	p Value
Baseline at 1 min	4 (6)	2 (4)	6 (5)	0.63
Baseline overall	4 (6)	2 (4)	6 (5)	0.63
Study at 1 min	24 (35)	27 (54)	51 (43)	0.054
Study overall	27 (40)	28 (56)	55 (46)	0.10

Percentages shown in parentheses.

motivation and enjoyment,¹⁵ and facilitate understanding.¹⁶ Mnemonics supply integration, meaning, and cues where none existed before.¹² Mnemonics may be verbal or visual and several types exist within these categories. Digital grouping entails “chunking” pieces of data together, for example a sequence of numbers is grouped into more manageable sizes and presentations thus 1998710267 becomes 199/87 and 102/67. Word linking or pegging may entail rhymes and jingles: for example, “Thirty days hath September”. In paired associations, the learner associates items of data with perhaps a series of rooms, which are encountered in a given sequence on a tour of a house.

Another type of mnemonic uses words or letters.¹² “4Hs and 4Ts” is an alphabet mnemonic, as is ABC for airway, breathing, and circulation. Acronym mnemonics are words formed from parts of items to be remembered, usually the first letter: NAVY for nerve, artery, vein, “Y fronts” indicating the femoral anatomy sequence. Acrostic mnemonics use specially arranged words to trigger important information; “A Badly Controlled Delivery Means Disasters Can Happen” represents Airway, Breathing, Circulation and fluids, Drugs,

Monitor and batteries, Documentation, Communication, Heat—factors in transporting a critically ill patient.

The primary end points, recall at one minute and overall, and the proportions of the groups gaining a maximum score of eight, all had p values close to 0.05. The ceiling effect of a maximum possible correct score may serve to limit the revelation of the full potential benefit of the aide memoires, particularly “EMD aide”. Despite recent training and regular clinical exposure on the arrest team, the use of “4Hs and 4Ts” seems comparatively ineffective with modest baseline recall and moderate improvement in “4Hs and 4Ts” study arm. The greater performance improvement in the EMD-aide arm, may be related to the greater organisation, order, and pictorial presentation. However, the time spent studying the aide memoires was significantly longer in the “EMD aide” group as this aide memoire is novel and more complex. Our methodology does not allow us to determine whether it was the extra time spent studying the aide memoire or the aide memoire itself that may be responsible for the (statistically marginal) improved outcome. However, the distinction may be a matter of semantics if the end point is better recall.

Table 3 Baseline results: percentage of HOs identifying causes of EMD. Thirty four per cent of HOs identified hypoxia as a cause of EMD (at any point in the sequence) at one minute

	4Hs+4Ts		EMD-aide	
	1 min	Overall	1 min	Overall
Hypoxia	34	35	25	27
Hypovolaemia	82	82	78	82
Pulmonary embolism	63	68	57	59
Pericardial tamponade	79	82	80	84
Pneumothorax (tension)	74	75	80	82
Electrolyte and metabolic	84	85	73	75
(Massive) hypothermia	76	78	73	76
Drugs and toxins	40	49	45	47

There are other limitations of this study. A fully randomised controlled trial (RCT) would have been preferable but our scepticism was well founded as many HOs did discuss the study and aide memoires with colleagues and there was a corporate acknowledgement of poor performance and a desire to improve, which would have confounded a trial randomising HOs. Furthermore, communication, cooperation, and motivation factors made HOs less than ideal subjects for such a trial. Telephone surveys and studies pose particular problems. HOs would have had opportunity to revise the causes of EMD between the baseline and post-intervention parts of the study but this factor should be equally prevalent in each arm of the study, one of the strengths of RCTs.

Contributors

Sarah Hughes participated in the conception of the paper, gathered some of the data, and was involved in editing the paper. Elsbeth Dyson helped in the study design and gathering of data as well as contributing to writing the paper. Sarah Voisey helped in the study design and gathering of data as well as contributing to writing the paper. Bernard Higgins was responsible for statistical advice and analysis. Peter J McQuillan conceived the idea, designed the protocol, coordinated the data, wrote the paper, and acts as guarantor for the study.

A copy of the EMD-aide in colour is available on the journal web site (<http://www.emjonline.com/supplemental>)

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Appendix Explanation of the educational and psychological cues used in "EMD-aide" (please visit the journal web site to view the EMD-aide in colour <http://www.emjonline.com/supplemental>)

EMD-AIDE

This diagram is designed to help doctors

- recall the causes of EMD (Electro-Mechanical Dissociation) or PEA (Pulseless Electrical Activity)
- recall in a sequence of therapeutic importance since some causes are more common and are more easily reversed than others

A The central octagon indicates there are eight causes of EMD/PEA

B There are four groups of causes, which are organised by... shape, colour, position, numbering + clockwise sequence, use of arrows

1. Hypoxia

- blue to denote cyanosis
- rounded shape + one arrow indicating only one cause in this "group"
- first in the clockwise sequence to denote that hypoxia is common and may be easily and immediately treated with oxygen

2. Hypovolaemia

- white to denote pallor
- rounded shape + one arrow indicating only one cause in this "group"
- second in the clockwise sequence to indicate it is common and can be easily and immediately treated with fluid

3. Obstruction to the circulation

- may occur either within the vasculature (**P**ulmonary embolism) or by extrinsic compression of the vasculature by a **P**neumothorax under tension or by **P**ericardial tamponade
- hence the obstructive three, the 3Ps
- three causes hence a (large) triangle + three arrows
- red colour to denote suffusion or congestion behind the obstruction
- third in the clockwise sequence, less common than hypoxia and hypovolaemia
- may be readily treated by thrombolytic therapy (pulmonary embolism), needle thoracocentesis and definitive chest drain (pneumothorax under tension) and pericardial tap and drainage (pericardial tamponade)

4. The miscellaneous fourth (EMD) group

- three causes hence a (smaller) triangle + three arrows
- is green to denote **E**lectrolyte + metabolic, **M**assive hypothermia and **D**rug causes
- green triangle is smaller with smaller print because the causes are less common and less amenable to immediate reversal

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