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The enhancement of intra-operative diagnostics and decision-making using computational methods

Michael J. Harrison
MB, BS (Newcastle upon Tyne), FRCA, FANZCA

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The University of Auckland, 2005

ABSTRACT

The data presented and views expressed in this document are the result of multiple published and unpublished studies over the last 25 years. My over-arching goal in this research was to use modern computing power to create functionally useful diagnoses, in real time, from the monitoring systems used during routine anaesthesia and to present these diagnoses in an ergonomic manner. In addition it was intended to incorporate into the anaesthetic monitor, expert systems that help with the management of uncommon situations.

The Australian and New Zealand College guidelines on monitoring during anaesthesia dictate those measurements that should be made during every anaesthetic; from these data evidence can be gathered, integrated, and presented to the clinician. Constraints in this field of research include the inability of the monitors to see, hear or understand the context of operating theatre activities, and computer processing time.

Because many studies are involved the methods are detailed in the main text, and are not summarized here.

Physiological 'envelopes' have been developed, in which the ‘normal’ variation in physiological variables, during anaesthesia, are enclosed. They have enabled the creation of intelligent alarm systems that can suggest diagnoses. A retrospective off-line study showed that it was possible to diagnose the onset of malignant hyperpyrexia, using fuzzy logic templates, about 10minutes earlier than the clinician. Some variables may be more important than others in making a diagnosis, and the strength of a diagnosis depends on the amount of supporting evidence, the amount of evidence not against the diagnosis and the amount of missing data.

Decision-making (for example to transfuse or not transfuse blood) can also be mathematically modelled so that decision making is more consistent.

Finally, investigation of the ways of displaying data indicates that the output can be very explicit.

My overall conclusion is that real time decision support systems for the management of clinical dilemmas are possible. They can be instantly and easily accessible and can sit discretely in the background of anaesthetic monitors to be activated at will by the anaesthetist.

PREFACE

STATEMENT OF WORK
ACKNOWLEDGEMENTS
PUBLICATIONS AND PRESENTATIONS

STATEMENT OF WORK

The work for this thesis has been carried out over twenty-five years. It began whilst I was working as a Consultant Anaesthetist and Senior Lecturer in Anaesthesia in the city of Nottingham, in the UK. The work was continued in Auckland, at Auckland Hospital, and as an honorary Senior Lecturer and Associate Professor in the Department of Anaesthesiology, Faculty of Medical and Health Science, University of Auckland, New Zealand.

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It is likely that this work will expose my ignorance more than my knowledge. Being pragmatic I hope the end result may be of use to someone with greater skills.

Michael Harrison
September 22nd, 2005

PUBLICATIONS AND PRESENTATIONS

The following publications arose from this work:

My contribution to these publications is tabulated in detail in APPENDIX H

Harrison MJ, Johnson F. Computer assisted decision making in anaesthesia. Br J Anaes 1980; 629P

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Jones RW, Lowe A, Harrison. MJ. Medical diagnosis using evidence based reasoning. Proceedings of the ICSC Symposia 0n Engineering of Intelligent Systems EIS 2000.ISBN 3-906454-21-5

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A Rules Based Guide to Anaesthesia, Harrison MJ, Jones RM, Pollard BJ.Butterworth 1986 ISBN BE-0407002987

Anaesthesia for Uncommon Diseases, Pollard BJ, Harrison MJ. Blackwell Scientific.

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LIST OF ABBREVIATIONS

AI	Artificial intelligence
ASA	American Society Anaesthesiologists' assessment score (I – V E)
BIS	Bi-spectral index
BLR	Binary logistic regression
BP	Blood pressure
BPV	Blood pressure variability
CHF	Congestive heart failure
CJA	Clinical judgment analysis
CO	Cardiac output
COPD	Chronic obstructive pulmonary disease
COR	Cardiac output reserve
COR	Clinical operating range (for physiological variables)
CVP	Central venous pressure
Des	Desflurane
DSS	Decision Support System
ECG	Electrocardiogram
E_TAA	End-tidal concentration of anaesthetic agent
E_TCO2	End-tidal concentration of carbon dioxide
F_EO2	Fractional expired concentration of oxygen
FFT	Fast Fourier Transform
F_IAA	Fractional inspired concentration of anaesthetic agent
F_ICO2	Fractional inspired concentration of carbon dioxide
F_IO2	Fractional inspired concentration of oxygen
FN	False negative
FP	False positive
gdL^{-1}	Grams per decilitre
Hal	Halothane
Hb	Haemoglobin or haemoglobin concentration
HF	High frequency
HRV	Heart rate variability
IABP	Intra-arterial blood pressure
IPPV	Intermittent positive pressure ventilation
Iso	Isoflurane
kPa	kilo Pascal
LF	Low frequency
LRE	Logistic regression equation
MAC	Minimum alveolar concentration
MAP	Mean arterial blood pressure
MOV	Mode of ventilation
N_2O	Nitrous oxide
NIBP	Non invasive blood pressure
NMT	Neuromuscular transmission monitor
NN	Neural networks
NPV	Negative predictive value
NZ	New Zealand
OGH	Ongoing haemorrhage
ON	Oxygen need
P1	Invasive arterial pressure channel on Datex-Ohmeda monitor

P(E)	Probability of the individual being in a subset
P(H)	Unconditional probability of event H
PA	Pulmonary artery
PCF	Patient condition factor
PCWP	Pulmonary capillary wedge pressure
PE (H)	Probability of the event occurring if patient was in subset
PH (E)	Fraction of events in a set of patients
Pleth	Plethysmographic trace from pulse-oximeter
PPNT	Peer pressure not to transfuse
PPT	Peer pressure to transfuse
PPV	Positive predictive value
PR	Pulse rate
Pt	Patient
PVD	Peripheral vascular disease
RAPV	Respiratory-related arterial pressure variability
ROTH	Risk of tissue hypoxia
RR	Respiratory rate
RRV	Respiratory rate variability
SBP / SABP	Systolic blood pressure / Systolic arterial blood pressure
Sevo	Sevoflurane
SNA	Sympathetic nervous activity
SpO2	Oxygen saturation of Hb measured using pulse-oximetry
SPV	Systolic pressure variability
SQL	Structured Query Language
TIA	Transient ischaemic attack (transient cerebral ischaemia)
TN	True negative
TP	True positive
TSW	Time series workbench
TTS	Trigg's tracking signal
TURP	Transurethral resection of prostate
Tx	Transfusion
V (max, min, ave)	Variable (maximum, minimum, average)
VAS	Visual analogue scale
Xt	Value of variable X at time t
y	'year old' as in '80y'

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