

PRELIMINARY COMPARISON OF ABSOLUTE AND RELATIVE RULES FOR IDENTIFYING HYPERTENSION IN CHILDREN DURING ANESTHESIA

Jonathan Stinson, BSc¹; Dorothy Myers¹; Dustin Dunsmuir¹; Christopher J Brouse²; J Mark Ansermino¹

¹Department of Anesthesiology, Pharmacology & Therapeutics, The University of British Columbia, Vancouver, British Columbia, Canada

²Department of Electrical & Computer Engineering, The University of British Columbia, Vancouver, British Columbia, Canada

Introduction: Blood pressure measurements in children during anesthesia are routinely performed and change alerts typically use absolute threshold values. As intraoperative hypertension is uncommon in children, a literature review yielded no previous publications addressing the event. In adults, however, acute intraoperative increases of blood pressure >20% are considered hypertensive emergencies (1). We recently completed an evaluation of intraoperative hypotension rules for use in children (2). The same cases and method of evaluation were employed to define rules for the automated detection of hypertension.

Method: Following ethics approval, an expert system for anesthesia was evaluated during routine surgery in children (3). Cases were at least one hour in duration and encompassed a variety of surgical procedures. Non-invasive blood pressure (NIBP) measurements cycled every 3 minutes, and were recorded. Real time evaluation of events was completed with absolute threshold values and a limited selection of relative deviation rules. A larger set of relative rules was developed post hoc using a knowledge authoring tool (3). Relative rules were created to detect increases in mean NIBP over a moving historical window, using percent change or standard deviation limits with varying time delays. Retrospectively, one anesthesiologist evaluated the entire NIBP trend for each case and marked episodes of hypertension. The anesthesiologist's opinion was chosen as the gold standard for evaluation of each rule. The same cases were automatically evaluated with the assistance of a MATLAB program comparing this gold standard and the developed absolute and relative rules.

Results: Nineteen surgical procedures including 6 orthopaedic, 5 general, 4 urological, 3 dental, and 1 ENT (mean duration of 171.3 min) performed in children 1.0 to 17.7 years of age (mean 9.2 years) were evaluated. During real time evaluation, a cumulative total of 22 incidences of hypertension were marked, 13 of which were marked as clinically significant. Retrospective analysis by the anesthesiologist revealed 32 (gold standard) incidences of hypertension. A performance summary for both relative and absolute rules in the retrospective analysis is shown in Table 1.

Table 1: Retrospective performance summary of relative and absolute hypertension rules

RULE			RESULTS					
Deviation Above Mean NIBP	Time Frame (min)	Delay (min)	Detected Events*	Missed Events	False Events	Sensitivity (%)	PPV (%)	Ratio of False/Missed Events
15%	10	2	19	13	6	59.38	76.00	0.46
15%	10	3	16	16	4	50.00	80.00	0.25
15%	20	0	23	9	20	71.88	53.49	2.22
15%	20	2	23	9	13	71.88	63.89	1.44
15%	20	3	22	10	8	68.75	73.33	0.80
15%	30	0	25	7	21	78.13	54.35	3.00
15%	30	2	24	8	12	75.00	66.67	1.50
15%	30	3	20	12	7	62.50	74.07	0.58
20%	30	2	19	13	5	59.38	79.17	0.38
20%	30	3	17	15	2	53.13	89.47	0.13
2 SD	10	0	31	1	104	96.88	22.96	104.00
2 SD	10	2	4	28	0	12.50	100.00	0.00
3 SD	30	0	21	11	29	65.63	42.00	2.64
3 SD	30	2	6	26	7	18.75	46.15	0.27
ABSOLUTE THRESHOLD RULES								
Systolic NIBP ≥160.0 and ≤250 (Adult, 17.0 ≤ age (yr) ≥ 200.0)			0	3	0	0	---	0
Systolic NIBP ≥140.0 and ≤250 (Child, 1.0 ≤ age (yr) ≥ 16.9)			2	27	4	6.90	33.33	0.15

* Total events of clinically marked hypertension = 32; SD = standard deviations; PPV = positive predictive value

Discussion: Approximately 60% of alerts in real time evaluation of the initial combined absolute and relative rules were considered to be clinically useful. In the retrospective analysis, absolute rules were inadequate in the detection of hypertension in children during anesthesia, as was previously found in the detection of hypotension (2). The following general trends were seen in the data: sensitivity of a relative rule was increased with smaller deviations (15% vs 20% and 2 SD vs 3 SD), whereas PPV of a rule was increased with a longer historical window (30 vs 10 min) and baseline delay (2 vs 0 min). Relative rules provide a more robust detection; however, it was found that there are significantly more false alerts. Hypertension in children may be less clinically important than hypotension, which would allow a wider limit with longer delay to reduce nuisance alerts. Relative rules, specifically percentage change rules, detect hypertension in children during anesthesia better than absolute rules.