Hyperthermia resulting from tourniquet application in children

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Summary

An association between the use of tourniquets for limb surgery and a progressive increase in body temperature was noticed in paediatric patients in our institution. Because malignant hyperthermia is always a concern in these patients, it was decided to investigate this phenomenon. The anaesthetic records of 70 paediatric patients were studied and divided into three groups. Group I (32 patients) had unilateral lower limb procedures and Group II (24 patients) had bilateral lower limb procedures. Group III, the control group, consisted of 14 patients who had undergone superficial body procedures. The data were analysed by oneway analysis of variance (ANOVA), and comparison between groups was made by unpaired t-tests. The study confirmed our clinical impression of the association.

Introduction

Unexplained increases in body temperature during anaesthesia evoke the spectre of malignant hyperthermia, particularly in children where the incidence is reported to be higher than in adults *(1)*, and especially in those who have musculoskeletal deformities. We have noted a progressive increase in body temperature in many paediatric patients undergoing corrective orthopaedic procedures to the limbs. In these operations a tourniquet is invariably applied and inflated, sometimes for more than two hours and sometimes bilaterally. It has been our impression that this phenomenon is related to the use of tourniquets.

Patients and methods

Seventy records of patients who underwent anaesthesia and surgery in our institution for correction of talipes deformities were reviewed. Of these, 14 were discarded because of inadequate documentation. The remaining 56 records were studied. Patients were divided into two groups. Thirty two had unilateral lower limb procedures, Group I, and 24 had bilateral lower limb procedures, Group II. Group III consisted of 14 patients who had undergone hernia repair, orchidopexy or hypospadias repair. They were selected as a control group since they had also undergone superficial body surgery and were similarly draped, covered and anaesthetised. All patients were healthy (ASA I-II), had been apyrexial since admission and had received atropine approximately one hour preoperatively. Anthropometric data appear in Table I.

Anaesthesia was induced by inhalation of a mixture of halothane, nitrous oxide and oxygen, which was also used for maintenance. Most patients (70% Group I, 88% Group II and 75% Group III) also received pancuronium and were managed with controlled ventilation, the remainder being allowed to breathe spontaneously. A Mapelson D breathing system with an in-line heated humidifier (Fisher and Paykel or Cascade) was used for all patients, as was a warming blanket (Blanketrol). Infusion fluids were not warmed and no patient received blood or blood products. Mean ambient temperatures in our operating rooms are maintained at 21.35 °C±0.85. Monitoring included an ECG, blood pressure cuff (Doppler, oscillometry or auscultation), precordial stethoscope and core temperature (rectal or oesophageal). Temperature measurements were made using either a YSI 43TA thermometer with a series 400 probe or a Model 8200 Bailey instrument recorder and probes. The first measurement was made within a few minutes of induction of anaesthesia and subsequent measurements were made every 15 minutes.

TABLE I *Anthropometric data*

	Group I (1 limb)	*Group II (2 limbs)*	*Group III (control)*
Age			
years	0.3–12.0	0.5–9.0	0.6–12.0
mean	4.150	2.829	3.560
SD	2.801	2.651	2.875
Weight			
kg	6.5–56.0	6.3–35.0	7.2–46.5
mean	17.285	13.575	18.100
SD	9.901	6.870	9.510
BSA*			
m^2	0.33–1.29	0.21–1.17	0.39–1.41
mean	0.661	0.567	0.710
SD	0.215	0.235	0.255

* BSA Body surface area

Results

Results were analysed by one-way analysis of variance (ANOVA); comparison was made between groups using unpaired t-tests. *P*-values less than 0.05 were considered to be significant. Fig. 1 depicts recorded temperatures from zero to 150 minutes, but comparisons were not made beyond 120 minutes since there were too few patients for meaningful comparison. Table II presents a comparative analysis of the changes in temperature. The analysis of variance results clearly indicate that there is a difference in the rate of temperature increase among the three groups. The smaller difference between groups I and II is accounted for by the size of the population groups, since all

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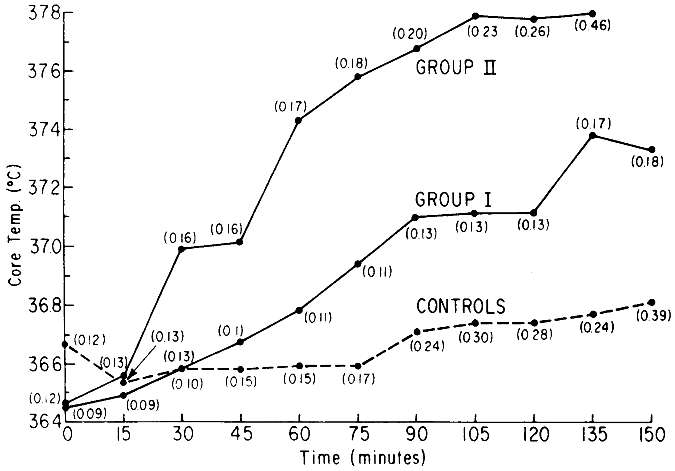

FIG. 1 Values are means (±SEM).

three groups have comparable standard deviations ranging from 0.5 to 0.9. Three patients (21%) in group I and two patients (6%) in group II showed either no increase in temperature or a small decline (mean 0.3°C). The largest increase over 120 minutes was 1.4°C in a patient in group I and 2.8°C in a patient in group II.

TABLE II *Temperatures—°C mean (SD)*

Group	*I (1 limb)*	*II (2 limbs)*	*III (controls)*
Initial	36.45	36.46	36.62
	(.52)	(.58)	(.42)
At 120 mins	37.16*	37.79*	36.77
	(.49)	(.85)	(.68)
Change	0.71*	1.33*	0.15
	(.39)	(.20)	(.58)

* $P \leq 0.01$ (t-test vs initial)

Discussion

In children, measures commonly taken to provide heat during anaesthesia include raising the ambient temperature, the use of a warming blanket under the patient, an overhead radiant heater, the warming and humidification of inspired anaesthetic gases, and the warming of infused fluids. These are effective in maintaining or increasing body temperature *(2)* and are especially important in paediatric patients undergoing operations involving body cavities. However, they can sometimes be excessively applied, and it is probably true that hyperthermia is now more common than hypothermia during paediatric anaesthesia because the latter has been stressed so much *(3)*. At our institution, a progressive increase in body temperature was noticed in many paediatric patients undergoing corrective orthopaedic procedures to the limbs. Because the increase in some patients was alarming and raised the possibility of malignant hyperthermia, we retrospectively studied the anaesthetic records of 56 patients who required corrective surgery. Our impressions were confirmed by the results.

Crocker *et al. (4)* found that, in patients undergoing general anaesthesia there were no significant differences in temperatures between patients receiving nondepolarising neuromuscular blocking drugs and those who had not, or between patients who had been premedicated with an anticholinergic drug, and those who had not. In children anaesthetised for 30 to 75 minutes with nitrous oxide oxygen and halothane for hernia repair, Engelman *et al.* noted a fall in temperature of 0.68°C *(5)*. We could therefore have anticipated little change in temperature in our patients.

However they were all well covered by up to three layers of drapes during the operation, the only area of the body not covered being most of the head and part of the limb or limbs being operated on. In children, when the buttock area is excluded as it would be in the case of a lower limb with an inflated tourniquet applied, one lower limb constitutes 15% of the body surface area (BSA) at 1 year of age *(6)*. If two limbs are isolated, approximately 30% of the BSA will be excluded from the surface heat exchange mechanism. When the tourniquet is inflated, the surface of the exposed limb or limbs is lost as a heat exchanger. Thus, when the whole body with the exception of part of the head is well covered, heat loss is reduced to a minimum. The net effect in a patient being actively warmed by the measures described above, is one of heat retention as evidenced by an increase in core temperature.

Because the onset of malignant hyperthermia is not always dramatic and may be insidious, it must always be considered when the body temperature rises during the course of an anaesthetic. However it is useful to know that there are other possibilities to be considered in such a situation.

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