TOURNIQUET-INDUCED HYPERTENSION

R. D. KAUFMAN AND L. F. WALTS

SUMMARY

The anaesthetic records of 500 patients undergoing lower limb surgery were reviewed to determine the frequency of intraoperative arterial hypertension (defined as a 30% increase in either systolic or diastolic pressure compared with the first pressure recording after incision). The overall frequency of hypertension during operation in 500 patients to whom a tourniquet was applied during surgery was 11%. The probability of hypertension was increased if the patient was elderly, had cardiac enlargement shown by x-ray or ecg, or had nitrous oxide and narcotic anaesthesia. Pre-existing hypertension, increased serum creatinine concentration, anaemia, or treatment with antihypertensives, diuretics, or steroids were not strongly associated with intraoperative hypertension. A control group of 100 patients undergoing hip surgery without application of a tourniquet exhibited hypertension in 1% of cases.

While administering anaesthesia for orthopaedic operations on the lower limb, the authors noted that a significant number of patients developed alarming increases in arterial pressure. This hypertension seemed to follow inflation of a thigh tourniquet and, even more striking, the pressure usually returned to near normal values shortly after the tourniquet was released. To determine the frequency of hypertension and possible predictors of the development of hypertension, we conducted a retrospective review of 600 anaesthetics given to patients undergoing leg operations.

METHODS

Records were obtained for 600 patients having operations on the lower limb, all performed in 1978. Five hundred patients had operations necessitating the use of a thigh tourniquet. The additional 100 patients (control group) underwent total and surface hip arthroplasty that did not necessitate the use of a tourniquet. All operations were carried out by the same group of surgeons, and took place in the same operating room. Anaesthesia was administered, in nearly every case, by the same team. The preoperative evaluation of these patients was reviewed to determine the presence of cardiovascular or renal disease and general information such as age, sex, and race. The type of anaesthesia and, in the case of general anaesthesia, the agents used were recorded. These data were correlated with the occurrence of hypertension. Statistical significance of continuous variables was determined by applying Student’s t test. The Fisher exact test (two-tail) was applied to dichotomous variables.

The arterial pressures measured on the day of admission to the hospital, immediately before the induction of anaesthesia and following the incision were noted. During the operation the pressure was recorded at 5-min intervals. Since arterial pressure may vary before operation (because of anxiety) and may be decreased after the induction of anaesthesia, the first pressure reading obtained after the operation was in progress was selected as a baseline; this was the first reading taken after inflation of the tourniquet, or the first reading after incision. Since incision usually followed inflation of the tourniquet by 1 or 2 min, the first pressure measurement after tourniquet inflation and after incision were usually the same measurement. Hypertension was defined as a 30% increase from baseline in either the systolic or diastolic pressure.

RESULTS

In the tourniquet group, various anaesthetics were used: halothane (150 patients), enflurane (117), nitrous oxide and narcotic (44), regional block (153) and more than one of these in 34 patients. These last 34 patients had undergone attempted regional block which failed or did not

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last for an adequate time or was supplemented with nitrous oxide. Fifty-five of the patients (11%) became hypertensive during operation.

Anaesthesia for the control group was halothane (56 patients), enflurane (20), nitrous oxide and narcotic (19), regional block (two), other (three). One patient became hypertensive during operation.

A multivariate analysis by logistic regression was made on all of the risk factors. This analysis determined type of anaesthesia, cardiac enlargement and age to be the only significant factors. The hypertensive patients were older, had evidence of cardiac enlargement on e.c.g. or chest x-ray, and were more likely to have received nitrous oxide-narcotic anaesthesia. Table I summarizes the effect and interaction of the three risk factors. The probability of hypertension varies from 0.01 to 0.67, depending upon the combination of these risk factors. Pre-existing hypertension, a history of angina or myocardial infarction, a history of congestive heart failure, an increase in plasma creatinine, a decrease in serum potassium, anaemia or treatment with anti-hypertensive, diuretic or steroid drugs were all not significant. There was no difference in respect of weight or race and no significant difference in the volume of fluid administered during operation to hypertensive and non-hypertensive patients.

Using the coefficients of the logistic regression determined from the tourniquet group, the control group would have been expected to exhibit hypertension in 17 of the cases. However, only one patient of the control group met the criteria for post-incision hypertension.

The figure shows the distribution of baseline and greatest arterial pressures of the patients having hypertension. Note that seven patients had systolic pressures greater than 190 mm Hg, the highest value found on our records. The time to achieve the highest pressure in each case (latency) was often greater than 1 h.

**DISCUSSION**

The presence of the tourniquet appears to be the main precipitating factor in the hypertension noted. It is unlikely that a light level of anaesthesia could be incriminated, since the controls had equally traumatic procedures but did not become hypertensive. In addition, the long latency of the hypertension is not consistent with a light level of anaesthesia. In patients anaesthetized with potent vapours the level of anaesthesia would be expected to be deeper with time as the alveolar concentrations approached inspired concentration (Eger, 1974). Inspired concentrations were increased or additional amounts of a narcotic administered in response to the hypertension in some cases. Thus, the true frequency and severity of hypertension may have been underestimated.

The long latency of the hypertension is also inconsistent with a direct haemodynamic effect of the tourniquet. The leg is exsanginated with a rubber bandage before the tourniquet is inflated, causing a transfusion of blood to the central circulation. However, this transfusion, or any change of peripheral vascular resistance secondary to the tourniquet, should have a prompt effect. Bradford (1969) has shown that an increase in systolic pressure following placement of a tourniquet on one lower limb occurs within 15 min of cuff inflation, and averages only 18 mm Hg increase in pressure.

A mechanism compatible with a long latency is that proposed for tourniquet pain during spinal

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<th>Table I. Probability of hypertension as a function of anaesthesia, age and presence of cardiac enlargement</th>
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<td>Cardiac enlargement</td>
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anaesthesia (Cole, 1952). During low spinal block (T10 or lower) while a pneumatic tourniquet has been applied, the patient may complain of a severe dull ache in the leg, even though the cutaneous level of anaesthesia is above the level of the tourniquet. This pain becomes apparent 45–60 min after the tourniquet has been inflated, and is relieved immediately after release of the tourniquet. Although the mechanism of the pain is controversial (Egbert and Deas, 1962; Egbert, 1964; de Jong, 1964) it is thought to be mediated by unmyelinated, slow conducting C-fibres which traverse the sympathetic trunks before entering the spinal cord above the level of block (de Jong and Cullen, 1963). This “slow” pain is normally inhibited by earlier arriving “fast” pain impulses from myelinated A-δ fibres. Limb compression by the tourniquet causes loss of conduction in large nerve fibres before small ones. After about 30 min of tourniquet compression the A-δ fibres are blocked, thus removing inhibition from the still functioning small C-fibres.
The variable efficacy of different anaesthetics in preventing tourniquet hypertension could be explained by their ability to block the C-fibre afferents. A high spinal block should be completely effective. In addition, the ability of different general anaesthetics to abolish cardiovascular reflexes and to produce direct cardiac depression would modify the pressure response to the "slow" pain.

Anaesthetists frequently choose nitrous oxide-narcotic anaesthesia for old or fragile patients. If a patient in whom hypertension would be seriously detrimental is to undergo surgery requiring a tourniquet, then regional block, halothane or possibly enflurane anaesthesia should be considered.

REFERENCES


HYPERTENSION PROVOQUEE PAR UN GARROT

RESUME

On a reçu les feuilles d’anesthésie de 600 patients ayant subi un acte chirurgical du membre inférieur pour déterminer la fréquence de l’hypertension artérielle per-opératoire (définie comme une augmentation de 30% de la pression systolique ou diastolique comparée à la première pression mesurée pendant l’intervention après l’incision) La fréquence globale de l’hypertension per-opératoire chez 500 patients auxquels un garrot avait été posé pendant l’acte chirurgical était de 11%. Les risques d’hypertension étaient plus grands si le patient était âgé, avait une cardiomegalie documentée par le cliché thoracique ou l’e.c.g. ou recevait une anesthésie par morphinomiméthiques associés au protoxyde d’azote. Une hypertension pré-existante, une augmentation de la créatininémie, une anémie ou un traitement par des antihypertenseurs, des diurétiques ou des steroids ne se sont pas montrés fortement corréles à l’hypertension peropératoire. Un groupe témoin de 100 patients subissant une chirurgie de la hanche sans garrot a objectivé une hypertension dans 1% des cas.

HYPERTENSION DURCH BLUTLEERE

ZUSAMMENFASSUNG


HIPERTENSION INDUCIDA POR TORNIQUETE

SUMARIO

Los registros anestésicos de 600 pacientes sometidos a cirugía de los miembros inferiores fueron examinados para determinar la frecuencia de la hipertensión arterial intraoperatoria (definida como un 30% de aumento ya sea de la presión sistólica ya sea de la diastólica comparado con el primer registro de presión después de la incisión) La frecuencia general de hipertension durante la operación era de un 11% en 500 pacientes a los cuales se aplicó un torniquete durante la cirugía. La probabilidad de hipertension aumentó si el paciente tenía edad, sufría de un agrandamiento cardiaco visto en la radiografía o e c.g. o era sometido a una anestesia narcótica y por óxido nitroso. La hipertension preexistente, la concentración aumentada de creatinina en el suero, la anemia, o el tratamiento por antihipertensivos, diuréticos, o esteroides no fueron fuertemente asociados con la hipertension intraoperatoria. Un grupo de control de 100 pacientes sometidos a cirugía de la cadera sin administración de un torniquete mostraron una hipertensión en un 1% de los casos.