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Carpal Tunnel Pressure in the Acute Phase After Colles' Fracture

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Summary. In order to analyze the pressure on the carpal tunnel in the acute phase after Colles' fractures 13 patients were studied. The initial pressure and the variation after injection of a local anesthetic into the fracture hematoma, as well as the effects of increased volar flexion of the wrist, were measured using a wick catheter technique. Comparisons were made with a control group of ten healthy volunteers. The pressure was significantly higher in the fracture group than in the control group, and it increased significantly after injection of a local anesthetic into the fracture hematoma. A correlation was found between high increases after local anesthetic injection and high initial pressure. The pressure increased linearly with volar flexion of the wrist. There was a correlation between high increases due to volar flexion of the wrist and high initial pressure. The trauma itself causes increased carpal tunnel pressure due to edema and bleeding. Injection of a local anesthetic solution increases the fluid content of the carpal tunnel and raises the pressure. Volar flexion of the wrist decreases the space in the carpal tunnel, which also increases the pressure.

The carpal tunnel syndrome is one of the most common complications of Colles' fracture [4], and it occures both in a chronic and in an acute form. The chronic form is associated with a rise in pressure in the carpal tunnel [3, 6]. Bauman et al. [1] have also observed pathologically elevated pressures in the carpal tunnel in four cases of acute carpal tunnel syndrome, but their measurements were performed up to 4 days after the injury. As far as the present authors know, there is only one report on carpal tunnel pressure in the acute stage after Colles' fracture in patients not exhibiting the carpal tunnel syndrome: Gelberman et al. [7] found the pressure to be 18 mm Hg when the wrist was held in a neutral position; the pressure increased when the wrist was moved to flexion or extension.

The mechanism of the pressure increase on injury is considered to be that the hemorrhage and edema that occur around the fracture communicate with the carpal tunnel, resulting in a rise in pressure [14]. A further addition to the volume of the fracture hematoma, for example on administration of a local anesthetic, could cause further elevation of the carpal tunnel pressure. In fact, Cooney et al. [4] reported that the frequency of neuritis of the median nerve was higher among patients treated with local infiltration of anesthesia into the fracture hematoma than among those in whom another form of anesthesia was used. Also, volar flexion of the wrist is considered to contribute to a pressure increase, by constriction of the carpal tunnel [2, 7, 10, 15].

This study was undertaken to measure the pressure in the carpal tunnel in the acute stage of Colles' fracture, to compare it with that in a control group, and to investigate the pressure changes occurring on administration of a local anesthetic into the fracture hematoma, as well as those induced by volar flexion of the wrist.

Patients and Method

There were 13 patients – 12 women and one man – with Colles' fractures in the acute stage. The patients were taken directly from the emergency department. All measurements were performed within 4 hours after the accident. The mean

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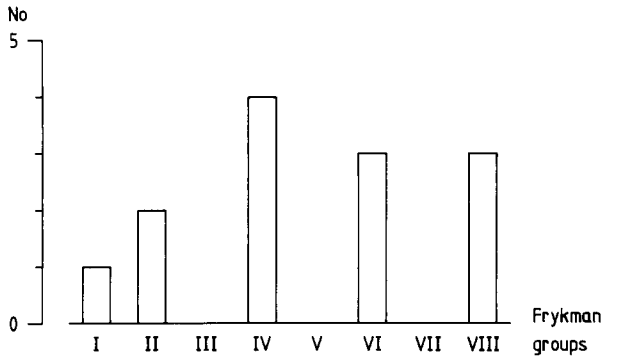

Fig. 1. Distribution of fracture classes according to Frykman [5]

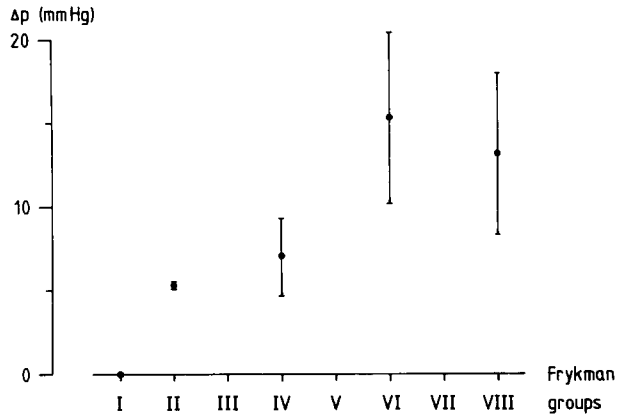

Fig. 2. Increase in carpal tunnel pressure in the various fracture classes according to Frykman [5] after injection of 10 ml of 1% lidocaine into the fracture hematoma. Means ± SE

age of the patients was 55 years, with a range of 36–66 years. The distribution into fracture classes as proposed by Frykman [5] is shown in Fig. 1.

The controls were ten healthy subjects – eight women and two men. Their mean age was 47 years, with a range of 35–75 years.

None of the persons, either in the fracture group or in the control group, were suffering from any systemic diseases, had had any previous injuries or affections of the wrist joints, or had any symptoms or signs indicating the chronic carpal tunnel syndrome.

The pressure measurements were performed with the wick catheter technique, according to the method of Mubarak et al. [13]. The catheter was inserted into the carpal tunnel as described by Gelberman et al. [6], under local skin anesthesia, and was connected to a pressure transducer. The pressures were registered on a recorder. Before every individual measurement the equipment was calibrated against a fluid column.

In the fracture group the pressure was measured first, before any manipulation of the fracture was performed. Then 10 ml of 1% lidocaine was injected into the fracture hematoma from the dorsal aspect of the wrist, after which the measurement was repeated. Thereafter, the fracture was reduced and the pressure was measured with the wrist in a neutral position and in 30° and 60° of volar flexion. "Neutral position" means that the second metacarpal bone lay in the extension of the longitudinal axis of the radius. In the control group measurements were performed with the wrist in the neutral position and in 30° and 60° of volar flexion. The student's *t*-test was used for statistical analysis.

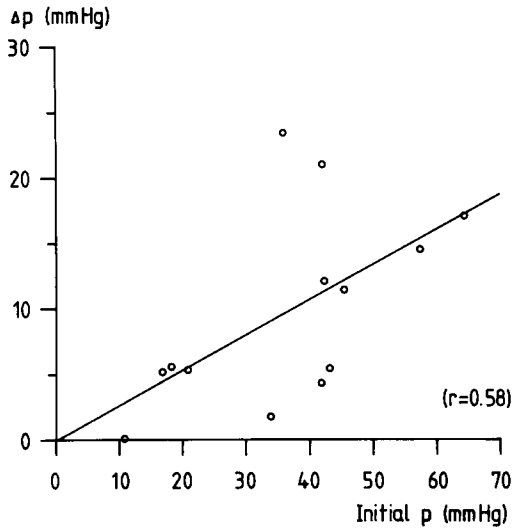

Fig. 3. Correlation between the increase in carpal tunnel pressure after injection of local anesthetic into the fracture hematoma and the initial carpal tunnel pressure

Results

The initial pressure in the fracture group was 36.4 ± 16.1 mmHg, as compared with 5.5 ± 3.5 mmHg in the control group ($P<0.001$).

After the injection of 10 ml local anesthetic, the pressure rose 9.6 ± 7.4 mmHg ($P<0.001$). This rise in pressure was less pronounced in patients with fractures of low Frykman classes (Fig. 2). Moreover, a greater pressure increase was noted in patients with high than in those with low initial pressures (Fig. 3).

Increasing volar flexion resulted in a significantly increasing pressure in both groups. The pressure in the control group remained at a lower level, however, and the rise in pressure on volar flexion was also smaller in controls than in the fracture group (Fig. 4). In the fracture group the average increase in pressure was 0.8 mmHg for every degree of increase in volar flexion. The increase was linear. As is evident form Fig. 5, the pressure rise on volar flexion was proportional to the initial pressure.

Discussion

Colles' fracture is the most common type of fracture in the body. Complications are very frequent. For example, Cooney et al. [4] reported a complication fre-

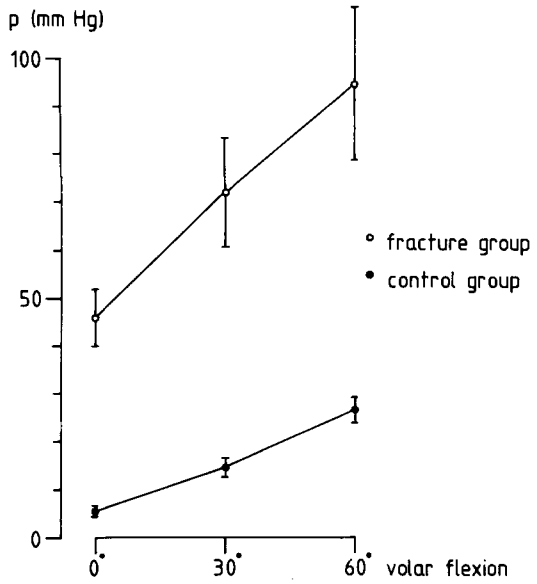

Fig. 4. Increase in carpal tunnel pressure as a result of increased volar flexion of the wrist in the fracture group and the control group. Means ± SE

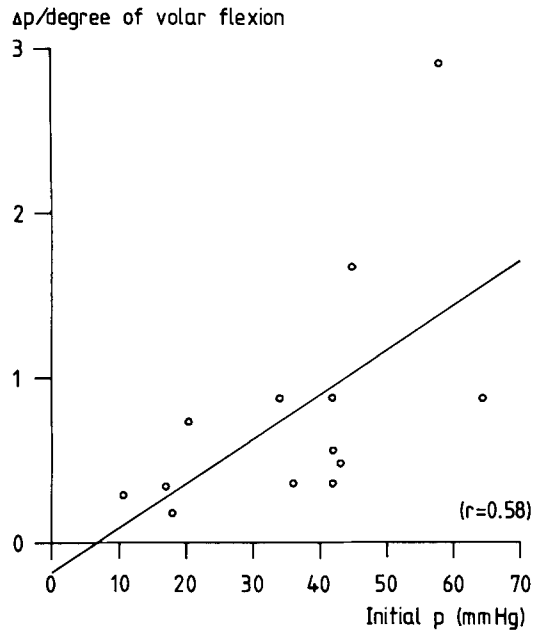

Fig. 5. Correlation between the increase in carpal tunnel pressure as a result of volar flexion of the wrist and the initial carpal tunnel pressure

quency of 74% after local anesthetic injection into the fracture hematoma. One of the most common complications is the carpal tunnel syndrome. This occurs in two forms, chronic and acute, both of which have been reported in association with Colles' fracture.

The chronic carpal tunnel syndrome is considered to be due to a rise in pressure in the carpal tunnel [3, 6], consequent to general or local edema or to a reduction of the volume of the carpal tunnel.

The acute form has been reported in only a few cases in the literature, mostly following trauma [1, 14, 16], but also in association with other acute conditions in the carpal region [8, 11, 12, 17]. In some cases of acute carpal tunnel syndrome after Colles' fracture, pathological pressures have been found [1].

The method used for measuring the pressures in this study was developed and described by Mubarak et al. [13]. It gives good static measurement results. The technique reacts slowly to pressure changes, but as no rapid events are to be expected, we consider it sufficiently reliable.

It is evident from this study that the pressure in the carpal tunnel is pathologically elevated after a Colles' fracture compared with that in healthy persons, in agreement with a previous report [7]. Injection of a local anesthetic into the fracture hematoma increases the pressure further; similarly, the pressure rises considerably with increasing volar flexion of the wrist.

On closer analysis it was found that the pressure was higher in fractures of higher Frykman classes than in lower ones. This may be explained by the fact that, according to the Frykman scheme, higher classes imply greater damage to the tissues and thus a greater degree of bleeding and extensive edema.

In the report by Gelberman et al. [7] both a pathologically elevated pressure and an increase of this pressure with increasing volar flexion of the wrist was found. There was no correlation between the severity of the injury and the pressure. In the present study, however, a tendency toward a correlation between the severity of the injury and the reaction to local anesthetic injection was seen. This tendency was also noted between the severity of the injury and the initial pressure. There is no obvious explanation for this difference. Perhaps it is due to the difference in time lapse between the injury and the registrations. In the American investigation this was long (average 10 h, range 2.5 h–5 days). We made the registrations much sooner after the accident, all within 4 h. This may also explain why we had an average pressure almost twice as high in the neutral position as Gelberman et al. [7] did (36 and 18 mm Hg respectively). Another drawback of the American investigation was that no attention was paid to the effect of the local anesthetic injection into the fracture hematoma; in 14 of their 25 cases this may well have obscured the results.

Furthermore, a correlation was found between high initial pressures and large pressure increases after administration of a constant volume of local anesthetic. The carpal tunnel may be conceived as an

enclosed space with a constant original volume. A given amount of blood and edematous fluid fills up a given portion of this space and results in a certain pressure. An increase in blood and edema leads to a rise in pressure and to a reduction of the remaining unfilled space. A given amount of local anesthetic will have a relatively greater impact on the pressure, the smaller unfilled space. Analogous reasoning can be applied to explain the finding that on volar flexion of the wrist the pressure increase is greater when the initial pressure is high than when it is low. In this case, it is the space in the carpal tunnel that decreases when the hand is volar flexed.

Lundborg et al. [9] report that the critical pressure level for nerve injuries lies between 30 and 60 mm Hg. As is evident from the present results, the combination of infiltration of a local anesthetic into the fracture hematoma and volar flexion of the hand leads to a rise in pressure to these dangerous levels. The reason an effect on the median nerve is not seen more often is probably that the pressure increase does not persist for a sufficiently long time. This study gives no information on the time course of the rise in pressure. For this, further investigations are required.

Thus, there are three factors that contribute to the increase in pressure in the carpal tunnel in the acute stage of Colles' fracture. The degree of trauma in itself is important, as it influences the magnitude of the hemorrhage and of the edema. Administration of a local anesthetic into the fracture hematoma and volar flexion of the wrist during the fixation are the other two factors. Of these three factors, two can be influenced by the physician treating the patient, namely the form of anesthesia and the fixation position.

The frequency of neurological complications of Colles' fracture can probably be reduced if consideration is paid to these conditions by choosing other forms of anesthesia and avoiding extreme volar flexion. Cooney et al. [4] observed that the frequency of neuritis of the medial nerve was lower among patients who were treated under brachial plexus anesthesia or general anesthesia than among those in whom a local anesthetic was injected into the fracture hematoma. In patients with fractures that are so unstable that they can be kept reduced only in a position of excessive volar flexion, a form of fixation other than a plaster cast should be considered, for example external fixation (Kongsholm and Olerud, to be published).

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