High-Pressure Injection Injuries of the Hand

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ABSTRACT: In high-pressure injection injuries to the hand the most commonly injected materials are automotive grease, diesel oil, and paint. We treated twenty-six patients with high-pressure injection injuries of the hand and found that the injection of paint resulted in a poorer prognosis than did the injection of grease. Amputation is often necessary with paint injections into a digit, while injections into the palm have a somewhat better prognosis. The disability time of patients with paint-injection injuries appeared to be directly related to the time elapsed until amputation of the involved digit. Although we were unable to specifically relate the ultimate result to the time elapsed between injury and proper treatment, we continue to recommend early aggressive wide débridement of these injuries.

High-pressure injection trauma to the hand is notoriously dangerous and often results in severe disability. Typically the foreign materials that may be injected are forced into the tissue under a pressure of 141 to 703 kilograms force per square centimeter. The long or the index finger is the usual site. The patient is generally a man who has been working at a new job for less than six months. He is first seen with a variable amount of swelling in the finger and palm and with a small puncture wound which may exude foreign material (Fig. 1). The material often extends down the flexor tendon sheath and may be visible on roentgenograms (Fig. 2). The tissues of the digit are thoroughly embedded with the foreign material (Fig. 3).

The degree of injury has been related to a number of different variables. The type of spray gun used was not found to be significant, but the type of material injected had a high correlation with the degree of injury. The materials most commonly injected are automotive grease containing mineral oil and hydrogenated castor wax, diesel oil containing petroleum-base white oil and polymethacrylate, and paint. Lubricating oils in high-pressure guns also contain impurities which produce intense inflammatory reactions. Spak listed five toxic materials which account for the severe inflammatory reaction associated with paint. In Kaufman’s series the greatest percentage of amputations were done in patients who had injections of paint. Diesel fuel oil and automotive grease were the next most common irritants.

Stark and associates found that the time interval between injury and proper treatment was the major factor in the final result. In six of seven patients treated within ten hours the ultimate condition of the digit was considered satisfactory. Results were progressively worse with greater delays in treatment.

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Many injuries of this kind result in amputation despite immediate and vigorous treatment. The lesser morbidity and much more rapid return to work in patients treated by amputation led Kaufman to conclude that primary amputation is often the procedure of choice.

In this paper we describe twenty-six patients with high-pressure injection injuries of the hand. We tried to determine which factors had the greatest influence on the ultimate function of the hand and what role early amputation played in the treatment regimen.

**Material and Methods**

The twenty-six patients with high-pressure injection injuries of the hand were treated at the Grace Hospital Hand Surgery Center between January 1962 and May 1974. Most of the patients were referred from outlying hospitals at varying intervals after the time of injury. The same treatment plan was followed for all patients: immediate wide surgical decompression, irrigation, and débridement with the wounds packed open or closed loosely over drains. Antibiotics were started immediately after material for culture had been taken and were continued for at least two weeks. A number of variables were defined and analyzed in light of the clinical course of the patients, each of whom was treated by one of us. Particular attention was paid to the initial appearance of the wound with associated erythema, pain, and swelling, as well as the apparent extent of soft-tissue dissection. Data on the interval between injury and initial treatment, as well as the type of material injected, was obtained. The nature of the injected material was confirmed at surgery. Posteroanterior, lateral, and oblique roentgenograms were made initially and at follow-up. We used four criteria to determine the final recovery rating: (1) pain, (2) mobility of the affected parts, (3) extent of anesthnesia, and (4) extent of chronic granulomatous changes. The final results were designated as good, fair, poor, or amputation. We considered amputation as a separate category rather than as a poor functional result. The patient's final rating was the lowest of any of the ratings just mentioned. The following variables were evaluated with respect to the final recovery rating: injection site, material injected, interval between injury and definitive treatment, sex, age, work experience, disability time, and presence of definite superinfection.

**Results**

*Injection site:* The index finger was the site of injection in twelve of the twenty-six patients, the long finger in six patients, the palm in four, the thumb in two, and the ring and little fingers in one patient each. The right hand was involved in fourteen patients and the left, in twelve.

*Material injected:* Seventeen of the twenty-six patients had injections of grease, six had injections of paint, and the remaining three had injections of these other materials: automotive undercoating, rust-proofing material, and hydraulic fluid. Table I shows the results with respect to the material injected. Five of the nine patients with amputations had paint injected. Eleven of the fifteen patients with fair or good results had injections of grease. These results support our conclusion and that of previous authors that the injection of paint into the hand has a poorer prognosis than does the injection of grease.

**Interval between injury and definitive treatment:** The elapsed time between injection and initial surgery ranged from less than twelve hours to fifty-three days, with a mean of 18.7 days. Eight of the patients with either fair or good results were operated on between one and ten days after the injury. Both of the patients with poor results were operated on less than twelve hours after the injury. Of the nine patients who ultimately had amputation, six received initial treatment less than twelve hours after injury. These results suggest that early definitive surgery does not guarantee a satisfactory result and that a surprising number of satisfactory results are obtained after later surgical treatment.

*Age, work experience, disability time, and infection:* All twenty-six patients in this series were men whose age at the time of injury did not correlate with the ultimate results. Thirty-seven per cent of the patients had had less than six months' experience with the injection gun. It was our impression after interviewing patients that, while most of these injuries were due to carelessness, a significant number of the patients had had little experience and had not been sufficiently warned of the dangers associated with the use of the high-pressure injection gun. The disability time in our series averaged seven months, the shortest time being one week. Aside from patients treated by early amputation who had a relatively short time of disability, there was no apparent association between the final results and the duration of disability. Since only three of the patients exhibited frank infections, no conclusions could be drawn about any association between results and infection.

**Discussion**

The index finger was the most frequently involved injection site in our series, as in others, but over half of our patients sustained injuries to the right hand (fourteen of twenty-six) in contrast to the large predominance of left-hand injuries previously reported. Stark and co-workers found that the interval between injury and the proper treatment was the major factor in the ultimate result. We were unable to confirm that conclusion. A relatively large number of patients in our series who were treated by early extensive surgery did not do as well as expected.
several of the patients with later surgery did better than expected.

In our series other factors took precedence prognostically over the time to treatment. The injected material had the most direct bearing on the ultimate result. Paint was the most toxic substance, oil the next, and grease the least. This finding was reported previously. Kaufman reported that the ejection pressure of the gun and the amount of material were the two factors that determined the extent of dispersion of materials in the hand. We could not test the ejection pressure of any of the guns used by our patients nor could we measure the volume of material injected. Nevertheless, those hands with the largest amount of injected material as judged by gross observation seemed to have poorer results. Ramos and associates reported that the pressure itself was not the cause of significant tissue damage but was instrumental in distributing materials more widely along tissue planes.

The site of injection was found to be important. The injection injuries in all of our patients were into the volar aspect of the digit or hand, but with injection into a digit the results were poorer than with injection into the palm. Although the number of our patients with injection in the palm was small (four cases), our findings were consistent with the data in the literature and may be explained by the fact that greater areas were available for tissue dispersion of the material in the palm, as compared with a digit.

Chronic inflammatory responses to the materials injected (oleogranulomas) occurred in a number of our patients, but resulted in considerable fibrosis with loss of mobility and function in only one patient.

The use of grease solvents was previously found to be ineffective in treatment, and Gillespie and associates also found that saline irrigation in rabbits was detrimental and in some cases may have encouraged septicemia. We gently irrigated most of our patients' wounds with saline and were not aware of any detrimental effects. Some authors used anti-inflammatory agents (steroids) and reported some beneficial results, but we did not use steroids in our patients.

It is generally impossible to remove all foreign material in injuries such as these and after a certain point extensive débridement appears to be harmful. If there was any evidence of extension from a digit into the palm or dorsum of the hand, we opened the affected area widely. This was necessary in most of our patients.

One final observation was the benefit of early amputation of severely injured digits. Kaufman pointed out that there was less morbidity associated with early ablative surgery. This led him to believe that primary treatment for the condition should often be amputation. With injuries to the thumb and palm, he recommended wide excision and radical débridement. Of the six patients with paint injections in our series, five eventually had amputation (83 percent) while a much smaller percentage of those injected with other materials ultimately had amputation (24 percent). Those patients treated with early amputation had a shorter period of morbidity and were able to return to work more quickly. This led us to conclude that in patients with severe paint-injection injuries of a digit, amputation is likely to be the ultimate result despite early definitive therapy; but when the injected material is not paint amputation as early treatment is contraindicated.

References