A Comprehensive Review of Epinephrine in the Finger: To Do or Not to Do

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The prohibition against the use of local anesthetics with epinephrine for digital blocks or infiltration is an established surgical tradition. The present article provides a comprehensive review of all reported digital necrotic and ischemic complications with epinephrine in the digits in an effort to understand whether the current prohibition is based on documented reports. A comprehensive review of articles showing the successful use of local anesthetic with epinephrine in the digits is presented.

A review of Index Medicus from 1880 to 1966 and a computer review of the National Library of Medicine database from 1966 to 2000 were performed using multiple keywords. Selected major textbooks from 1900 to 2000 were also reviewed.

A total of 48 cases of digital gangrene after anesthetic blocks (mostly using cocaine or procaine) have been reported in the world literature. Only 21 cases involved the use of epinephrine; 17 involved an unknown concentration based on manual dilution. Multiple other concurrent conditions (hot soaks, tight tourniquets, and infection) existed in these case reports, making it difficult to determine the exact cause of the tissue insult. There have been no case reports of digital gangrene using commercial lidocaine with epinephrine (introduced in 1948). Multiple studies involving thousands of patients support the premise that the use of lidocaine with epinephrine is safe in the digits.

An extensive literature review failed to provide consistent evidence that our current preparations of local anesthetics with epinephrine cause digital necrosis, although not all complications are necessarily reported. However, as with all techniques, caution is necessary to balance the risks of this technique with the dangers of mechanical tourniquets and upper extremity block anesthesia. (Plast. Reconstr. Surg. 108: 114, 2001)

One of the strongest admonitions given to medical students and residents is not to inject local anesthetics with epinephrine into the digits. This prohibition is promulgated by essentially all surgical, hand, plastic, and dermatological texts. A review of the world’s literature from the past 120 years documents 48 cases of digital necrosis from local anesthetics. None of these cases involved the use of Xylocaine (lidocaine), and only 21 entailed the use of epinephrine. The majority of cases occurred more than 50 years ago. At that time, epinephrine was diluted by hand.

The recent literature reports 15 cases of digital ischemia resulting from anesthetics with epinephrine, epinephrine solutions, or EpiPen injections. All were reversed, even those involving concentrated epinephrine (1:1000), if treated up to 13 hours after injury.

Digits have a great ability to withstand ischemic insults due to their structure, which has skin, tendons, ligaments, and bone, but no muscle. There are reports of finger replantation after 42 hours of warm ischemia. Although a bloodless field is necessary for hand surgery, the mechanical tourniquet is the only current recommendation. However, mechanical tourniquets have their own complications.

The present article provides (1) a comprehensive review of all reported necrotic and ischemic complications with epinephrine in the digits to understand whether the current prohibition is reasonable and (2) a comprehensive review of articles showing successful use of local anesthetic with epinephrine in the digits.

MATERIALS AND METHODS

A review by hand of Index Medicus from 1880 to 1966 was performed using the following headings: adrenal preparations, anesthesia, anesthetic complications, cocaine, lidocaine, local anesthesia, local anesthetics, and procaine. In addition, a review of major textbooks of anesthesia, orthopedics, and surgery was...
performed. National Library of Medicine computer searches from 1966 to 2000 were done using the following key words: chemically induced gangrene, epinephrine, epinephrine/ adverse effects, finger injuries/drug therapy, finger injuries/surgery, injections/subcutaneous, ischemia/chemically induced, lidocaine/ adverse effects, local anesthesia, local anesthetics/adverse effects, procaine, vasoconstriction, vasoconstrictor agents, sickle cell disease, and Raynaud’s, history.

Journal Review

The first use of local anesthesia in the West was reported by Karl Koller in his 1884 presentation on the use of cocaine in the eye.20 Subsequently, Burke21 performed the first digital nerve block, and Halsted reported the first major nerve block.22 Schleich introduced the concept of using dilute solutions of local anesthetics in an effort to reduce toxic complications.23 Klein24 recently popularized this technique.

Epinephrine was first isolated from the adrenal medulla in 1897 by Abel, who named it. Takamine25 isolated it in crystalline form and patented it as “Adrenalin” (epinephrine) in 1901. Cocaine was the only local anesthetic available until the introduction of procaine by Einhorn in 1904.26 Despite the fact that cocaine is a vasoconstrictor, there are few reported cases of digital necrosis27–32 with cocaine use.

In 1903, Braun33 popularized the addition of epinephrine (suprarenin or suprarenal extracts) to solutions of cocaine. He described the epinephrine effect as that of a “chemical tourniquet,” retarding the absorption of the cocaine and prolonging its effect. His first article documented three cases of finger anesthesia using a cocaine/epinephrine solution. Braun expressed mixed feelings about using epinephrine in the digits27,28,34: “if the action of suprarenin be too intense or long continued, gangrene of the tissues can occur, particularly if the nutrition of the part is already interfered with, as, for instance in arteriosclerosis of the extremities, wounds, or plastic flaps. Siebert35 has collected cases of this kind.” However, Braun did use epinephrine near the base of the finger “where the blood supply is more abundant”27 and recommended injecting “only a small amount.”36

Numerous authors began to address the problem of necrosis after local anesthesia in the 1920s. Ruben37 and Riccio and La Rossa38 concluded the causes were overdistension of tissues, poor surgical technique, or use of too much epinephrine.

In 1928, Moulonget39 reported a case of total gangrene of the index finger after an injection of plain procaine. However, hot soaks were used after surgery. Halla40 reported the first case of a digital block with epinephrine developing gangrene. His emphasized that the injury occurred from hot soaks after surgery.

In 1931, Garlock41 reported four cases of gangrene after digital blocks; however, none involved epinephrine. He considered the gangrene secondary to a tight tourniquet.

In 1933, Lambert and Snyers29 described two cases of procaine with epinephrine causing digital necrosis. They also tabulated 23 cases of digital necrosis after local anesthetics. Many of these cases are known only through their citations.32,35,42–47

In 1936, Hanke48 reported a case of digital necrosis after the resection of severe Dupuytren’s contracture. He injected 40 cc of procaine with epinephrine into the palm before surgery. No tourniquet was necessary.

In 1941, Kaufman30 reported a case of burns to a finger anesthetized with procaine and epinephrine. Kaufman collected cases of digital necrosis from the European and American literature. He thought contributing factors included peripheral arteriosclerosis, allergic reaction, injection of excessive amounts of solution, vasoconstriction due to epinephrine, vascular trauma from the tourniquet, and burns from hot soaks postoperatively.

In 1942, Pelner49 described a case of gangrene after the injection of procaine with epinephrine 1:50,000 into an ingrown toenail. He noted that commercial vials of anesthetics could contain epinephrine solutions as strong as 1:20,000. In his review, he opined that epinephrine was the cause of the tissue sloughs. However, a review of the articles he cited does not support this conclusion.

Also in 1942, McLaughlin50 reported on a patient who received digital block anesthesia with epinephrine (concentration unspecified). After surgery, the patient used hot soaks, which caused digital necrosis.

In 1944, O’Neil and Byrne51 reported eight cases of digital gangrene after digital nerve block anesthesia. In six cases epinephrine use was assumed, and seven of the cases involved hot soaks.
In 1947, Debeyre and Mattei reported two cases of digital gangrene after injections of local anesthetic. They recommended that general anesthetic be used in most cases.

De Rougemont and Carcassone, in a 1948 review of digital blocks, noted several reports of gangrene. Pointing out that gangrene of the finger could occur without epinephrine being used in digital blocks, they reported their own series of more than 1500 digital blocks using epinephrine 1:100,000 without digital necrosis.

In 1958, Burnham reported on his use of local anesthetics with 1:200,000 epinephrine in 93 digital blocks without complications. He recommended injecting small amounts of anesthetic at the area of the metacarpal heads and dorsally in the hand.

In 1963, Bradfield reviewed digital block anesthesia and its complications. He noted that there were 41 cases of gangrene after digital blocks. He added three cases of his own found by survey, although it is not known if epinephrine was used.

In 1967, Johnson reported his experiences using lidocaine with epinephrine in the hand and fingers. He documented 421 cases, without any incidence of digital gangrene. Most cases involved the hand rather than the finger, but at least 98 involved the finger. Johnson emphasized that this technique avoided the need for general anesthesia and a tourniquet.

Rank et al., in their 1968 book, strongly warned against the use of epinephrine in the fingers. They presented a photograph of a necrotic finger after local anesthetic block, but no details were provided in any edition.

In 1971, two articles advocated using epinephrine in local anesthetics for podiatry. Steinberg and Block used lidocaine with epinephrine in more than 200,000 injections into the foot, forefoot, and toes without seeing any necrosis or gangrene. They noted that digital tourniquets were unnecessary with the use of epinephrine. Kaplan and Kashuk also advocated using anesthetics with vasoconstrictors in the digits.

In 1974, Sandzen strongly condemned digital blocks. He presented a photograph of a necrotic finger after local anesthetic block, but no details.

In 1979, McGlamry recommended injecting lidocaine with epinephrine 1:100,000 for digital blocks. Gross questioned this recommendation; however, he considered a rubber-band tourniquet safer practice than the use of epinephrine.

In 1985, Earle and Blanchard used lidocaine with epinephrine for finger blocks at the level of the metacarpals.

In 1996, Farmer reported a case of partial digital necrosis in which the patient had local anesthetic with epinephrine injected into the finger by an ophthalmologist. Concentrations, type, and amounts of epinephrine or local anesthetic were not mentioned.

In 1998, Sylaidis and Logan described using 1:80,000 epinephrine in 100 consecutive cases. They reported no ischemic necrosis or gangrene.

In 1998, Wilhelmi et al. used epinephrine in 23 digital surgeries. They experienced no complications. After a literature review, they noted “no case has been reported in which epinephrine alone caused the complication of finger gangrene.” They pointed out that hot soaks were the cause of digital gangrene in most cases.

Textbook Review

Bunnell’s Surgery of the Hand, which first appeared in 1944, went through six editions. Bunnell preferred the use mechanical tourniquets instead of chemical tourniquets, although he was aware of severe complications from mechanical tourniquets and he documented no specific complications using epinephrine. The first edition contained several admonitions regarding the use of epinephrine in the fingers. Bunnell stated that “Adrenalin should never be injected into a digit, because from this gangrene has often resulted.” He referenced the work of McLaughlin and Kaufman, although Bunnell made no mention of the dangers of hot soaks. Bunnell’s second and third editions contained the same recommendations regarding epinephrine and added the reference by O’Neil and Byrne. Joseph Boyes, who authored the final two editions, kept Bunnell’s recommendations and references unchanged. Boyes acknowledged the dangers of using rubber-band tourniquets.

Frederick Christopher’s Minor Surgery encompassed eight editions between 1929 and 1967. The first edition recommended using procaine with epinephrine 1:200,000 for digital blocks. No mention was made of potential necrosis from the epinephrine, although he noted that fingers were “end arteries.” The
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<thead>
<tr>
<th>Case</th>
<th>Reference and Year</th>
<th>Clinical Problem</th>
<th>Surgery</th>
<th>Anesthetic and Quantity</th>
<th>Epinephrine Use</th>
<th>Tourniquet</th>
<th>Hot Soaks</th>
<th>Infection Present</th>
<th>Gangrene Extent</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Strauss, 1889</td>
<td>Ingrown toenail</td>
<td>Removal of nail</td>
<td>20% cocaine, unknown quantity</td>
<td>None</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>Entire digit</td>
<td>Citation only</td>
</tr>
<tr>
<td>2</td>
<td>Marcinowski, 1902</td>
<td>Paronychia</td>
<td>I&amp;D</td>
<td>3 cc of Eukain B</td>
<td>None</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>Mid-distal phalanx</td>
<td>Outdated anesthetic</td>
</tr>
<tr>
<td>3</td>
<td>Dejardin, 1917</td>
<td>Paronychia?</td>
<td>I&amp;D</td>
<td>1% cocaine, unknown quantity</td>
<td>None</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>Entire digit</td>
<td>Citation only</td>
</tr>
<tr>
<td>4</td>
<td>Siebert, 1910</td>
<td>Infected wound?</td>
<td>I&amp;D</td>
<td>Cocaine and Eukain B, unknown quantity</td>
<td>None</td>
<td>Yes</td>
<td>Unknown</td>
<td>Yes</td>
<td>Entire digit</td>
<td>Citation only</td>
</tr>
<tr>
<td>5</td>
<td>Siebert, 1910</td>
<td>Needle fragment?</td>
<td>Removal of needle</td>
<td>Cocaine and Eukain B, unknown quantity</td>
<td>None</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>Distal two phalanges</td>
<td>Citation only</td>
</tr>
<tr>
<td>6</td>
<td>Dejardin, 1917</td>
<td>Felon</td>
<td>I&amp;D</td>
<td>Sterile water, unknown quantity</td>
<td>None</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>Entire digit</td>
<td>Citation only</td>
</tr>
<tr>
<td>7</td>
<td>Dejardin, 1917</td>
<td>Traumatic amputation</td>
<td>Removal of phalanx</td>
<td>Procaine, unknown quantity</td>
<td>None</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>Entire digit</td>
<td>Citation only</td>
</tr>
<tr>
<td>8</td>
<td>Chevrier, 1927</td>
<td>Severed extensor tendon</td>
<td>Repair of tendon</td>
<td>Procaine-epinephrine, unknown quantity</td>
<td>No</td>
<td>Unknown</td>
<td>No</td>
<td>Unknown</td>
<td>Middle/distal phalanx</td>
<td>Citation only</td>
</tr>
<tr>
<td>9</td>
<td>Dinanian, 1928</td>
<td>Ingrown toenail</td>
<td>Removal of nail</td>
<td>Procaine-epinephrine, unknown quantity</td>
<td>Yes, 1:200,000</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Entire toe and metatarsal</td>
<td>Citation only</td>
</tr>
<tr>
<td>10</td>
<td>Moulonguet, 1928</td>
<td>Embedded needle</td>
<td>Removal of foreign body</td>
<td>3-4 cc of 0.5% procaine</td>
<td>None</td>
<td>No</td>
<td>Yes, warm soaks after surgery</td>
<td>Unknown</td>
<td>Entire digit</td>
<td></td>
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<tr>
<td>11</td>
<td>Toupet, 1928</td>
<td>Trophic nail disturbance</td>
<td>Excision</td>
<td>Procaine-epinephrine, unknown quantity</td>
<td>Yes, unknown concentration</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Entire toe</td>
<td>Possible vascular disease</td>
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<tr>
<td>12</td>
<td>Halla, 1928</td>
<td>Paronychia</td>
<td>I&amp;D</td>
<td>1-2 cc of 2% procaine-epinephrine</td>
<td>Yes, unknown concentration</td>
<td>No</td>
<td>Yes, digit soaked in boiling water for 30 minutes</td>
<td>Yes</td>
<td>Most of finger</td>
<td>Cautions against hot soaks</td>
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<td>13</td>
<td>Wolfsohn, 1928</td>
<td>Unknown</td>
<td>Unknown</td>
<td>8-10 cc of procaine-epinephrine</td>
<td>Yes, unknown concentration</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Terminal phalanx</td>
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<tr>
<td>14</td>
<td>Costantini et al, 1930</td>
<td>Unknown</td>
<td>Cocaine-epinephrine, unknown quantity</td>
<td>Yes, unknown concentration</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Entire digit</td>
<td>Citation only</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Costantini et al, 1930</td>
<td>Unknown</td>
<td>Cocaine-epinephrine, unknown quantity</td>
<td>Yes, unknown concentration</td>
<td>No</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Entire digit</td>
<td>Citation only</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Makai, 1932</td>
<td>Paronychia</td>
<td>I&amp;D</td>
<td>2 cc of 1% procaine-epinephrine</td>
<td>Yes, 1:200,000</td>
<td>Yes, for 2 minutes</td>
<td>Yes</td>
<td>Small slough at distal phalanx</td>
<td>Citation only</td>
<td></td>
</tr>
<tr>
<td>Case</td>
<td>Reference and Year</td>
<td>Clinical Problem</td>
<td>Surgery</td>
<td>Anesthetic and Quantity</td>
<td>Epinephrine Use</td>
<td>Tourniquet</td>
<td>Hot Soaks</td>
<td>Infection Present</td>
<td>Gangrene Extent</td>
<td>Remarks</td>
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<tr>
<td>17</td>
<td>Makai, 1932</td>
<td>Ingrown toenail</td>
<td>Resection of nail</td>
<td>2–3 cc of 1% procaine at the base</td>
<td>Yes, unknown concentration</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>Small slough at injection site</td>
<td>Advised checking circulation postoperatively</td>
</tr>
<tr>
<td>18</td>
<td>Garlock, 1931</td>
<td>Embedded needle</td>
<td>Removal of needle</td>
<td>Unknown quantity of 1% procaine distal to tourniquet</td>
<td>None</td>
<td>Yes, rubber band 30 minutes</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Gangrene started 2 days later</td>
<td>Marked delay in gangrene</td>
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<tr>
<td>19</td>
<td>Garlock, 1931</td>
<td>Paronychia I&amp;D</td>
<td>Unknown quantity of 1% procaine distal to tourniquet</td>
<td>None</td>
<td>Yes, tight rubber band for 15 minutes</td>
<td>Unknown</td>
<td>Yes</td>
<td>Amputation at the PIP joint from thrombosed vessels</td>
<td>No epinephrine; blue/cold finger noted next day</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Garlock, 1931</td>
<td>Felon from wood splinter</td>
<td>I&amp;D</td>
<td>Unknown quantity of procaine</td>
<td>None</td>
<td>Yes, thin tourniquet</td>
<td>Yes, warm soaks</td>
<td>Yes, chronic infection</td>
<td>Gangrene to MCP, dorsal and DIP volar</td>
<td>No epinephrine, tight tourniquet</td>
</tr>
<tr>
<td>21</td>
<td>Garlock, 1931</td>
<td>Embedded needle</td>
<td>Removal of needle</td>
<td>6 cc of 1% procaine distal to tourniquet</td>
<td>None</td>
<td>Yes catheter for 1 hour</td>
<td>Unknown</td>
<td>Infection present</td>
<td>IP joint amputation</td>
<td>Thumb bled at conclusion of case</td>
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<tr>
<td>22</td>
<td>Heinicke, 1932</td>
<td>Melanoma of great toe</td>
<td>Wide excision</td>
<td>25–30 cc of 0.5% procaine-epinephrine</td>
<td>Yes, unknown concentration</td>
<td>No</td>
<td>Unknown</td>
<td>No</td>
<td>Tip of toe</td>
<td>Advised pancreatic extract injections</td>
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<tr>
<td>23</td>
<td>Kirchbach, 1932</td>
<td>Ingrown toenail</td>
<td>Nail avulsion and curettage</td>
<td>8 cc of 0.25% procaine, unknown quantity</td>
<td>Yes, 1:400,000</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>Localized gangrene in area of infiltration</td>
<td>Gangrene started 2 days later</td>
</tr>
<tr>
<td>24</td>
<td>Rupp, 1932</td>
<td>Paronychia I&amp;D</td>
<td>10–15 cc of 0.5% procaine-epinephrine</td>
<td>Yes, unknown concentration</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>Entire digit</td>
<td>Not in Lambert and Snyers</td>
<td></td>
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<tr>
<td>25</td>
<td>Rupp, 1932</td>
<td>Ingrown toenail</td>
<td>I&amp;D</td>
<td>Unknown quantity of anesthetic procaine-epinephrine</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes</td>
<td>Unknown</td>
<td>Not in Lambert and Snyers</td>
</tr>
<tr>
<td>26</td>
<td>Delgoffe, 1933</td>
<td>Chronic osteitis of terminal phalanx</td>
<td>Removal of chronic osteitis of nail</td>
<td>5–8 cc of 1% procaine</td>
<td>None</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>Amputation 50 days later</td>
<td>Citation only</td>
</tr>
<tr>
<td>27</td>
<td>Lambert and Snyers, 1933</td>
<td>Embedded foreign body</td>
<td>5 cc of 2% procaine-epinephrine</td>
<td>Yes, unknown concentration</td>
<td>No</td>
<td>Unknown</td>
<td>Yes</td>
<td>Gangrene to level of injection</td>
<td>Unknown</td>
<td>Amputation 50 days later</td>
</tr>
<tr>
<td>28</td>
<td>Lambert and Snyers, 1933</td>
<td>Paronychia I&amp;D</td>
<td>2.5 cc of procaine-epinephrine</td>
<td>Yes, unknown concentration</td>
<td>Yes</td>
<td>Unknown</td>
<td>Yes</td>
<td>Gangrene to level of proximal injection</td>
<td>Unknown</td>
<td>Amputation 50 days later</td>
</tr>
<tr>
<td>29</td>
<td>Hanke, 1936</td>
<td>Dupuytren’s contracture</td>
<td>Total fasciectomy</td>
<td>40 cc of procaine</td>
<td>Yes, unknown concentration</td>
<td>No</td>
<td>Unknown</td>
<td>No</td>
<td>Gangrene distal to DIP in long and ring fingertips</td>
<td>Huge volume of anesthetic</td>
</tr>
<tr>
<td>30</td>
<td>Kaufman, 1941</td>
<td>Felon</td>
<td>I&amp;D</td>
<td>4 cc of 2% procaine-epinephrine</td>
<td>Yes, unknown concentration</td>
<td>No</td>
<td>Finger soaked in hot boiling water</td>
<td>Yes</td>
<td>IP joint amputation</td>
<td>Third-degree burns</td>
</tr>
<tr>
<td>31</td>
<td>McLaughlin, 1942</td>
<td>Paronychia of middle finger</td>
<td>I&amp;D</td>
<td>3 cc of procaine-epinephrine</td>
<td>Yes, unknown concentration</td>
<td>Unknown</td>
<td>Yes</td>
<td>Yes, boric acid hot soaks</td>
<td>Mid phalanx</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>Cutler, 1942</td>
<td>Paronychia I&amp;D</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Distal phalanx Gangrene and amputation</td>
<td>Photograph only</td>
</tr>
<tr>
<td>33</td>
<td>O’Neil and Byrne, 1944</td>
<td>Abscess on tip of finger</td>
<td>I&amp;D</td>
<td>Unknown anesthetic for digital block</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes, hot water soaks</td>
<td>Known</td>
<td>Distal phalanx Gangrene and amputation</td>
<td>A burn under digital block</td>
</tr>
</tbody>
</table>

**TABLE I**

Digital Gangrene and Necrosis after Local Anesthesia in the Digits
### TABLE I
Digital Gangrene and Necrosis after Local Anesthesia in the Digits

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<tr>
<th>Case</th>
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<th>Anesthetic and Quantity</th>
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<th>Infection Present</th>
<th>Gangrene Extent</th>
<th>Remarks</th>
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</thead>
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<tr>
<td>34</td>
<td>O’Neil and Byrne, 1944</td>
<td>Paronychia</td>
<td>I&amp;D</td>
<td>Procaine, unknown concentration and amount</td>
<td>Unknown</td>
<td>No</td>
<td>Yes, warm water soaks</td>
<td>Yes</td>
<td>Distal third gangrene/amputation</td>
<td>A burn under digital block</td>
</tr>
<tr>
<td>35</td>
<td>O’Neil and Byrne, 1944</td>
<td>Traumatic fracture laceration over middle phalanx</td>
<td>Repair of laceration and fracture</td>
<td>15 cc of 2% procaine without epinephrine</td>
<td>No</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Amputated at proximal phalanx</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>O’Neil and Byrne, 1944</td>
<td>Chronic paronychia</td>
<td>Removal of nail</td>
<td>Unknown type and amount of anesthetic</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes, hot water soaks</td>
<td>Yes</td>
<td>Gangrene of distal portion</td>
<td>A burn under digital block</td>
</tr>
<tr>
<td>37</td>
<td>O’Neil and Byrne, 1944</td>
<td>Infected finger</td>
<td>Unknown</td>
<td>Unknown type and amount of anesthetic</td>
<td>Unknown</td>
<td>Yes, elastic for 45 minutes</td>
<td>Yes, temperature unknown</td>
<td>Yes</td>
<td>Middle phalanx amputation</td>
<td>A burn from hot soaks</td>
</tr>
<tr>
<td>38</td>
<td>O’Neil and Byrne, 1944</td>
<td>Paronychia</td>
<td>I&amp;D</td>
<td>4 cc of procaine-epinephrine solution</td>
<td>Yes, unknown concentration</td>
<td>No</td>
<td>Yes, very warm water</td>
<td>Yes</td>
<td>Amputation at the middle phalanx</td>
<td></td>
</tr>
<tr>
<td>39</td>
<td>O’Neil and Byrne, 1944</td>
<td>Paronychia</td>
<td>I&amp;D</td>
<td>Unknown quantity of procaine-epinephrine solution</td>
<td>Yes, unknown concentration</td>
<td>No</td>
<td>Yes, soaks as hot as patient could stand</td>
<td>Yes</td>
<td>Entire finger burned</td>
<td>Stiff finger</td>
</tr>
<tr>
<td>40</td>
<td>O’Neil and Byrne, 1944</td>
<td>Subungual hematoma</td>
<td>Incision</td>
<td>Unknown quantity of procaine</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes, hot soaks</td>
<td>No</td>
<td>Amputation of distal phalanx</td>
<td>Burned finger from hot soaks</td>
</tr>
<tr>
<td>41</td>
<td>Debeyre and Mattei, 1947</td>
<td>Paronychia</td>
<td>I&amp;D</td>
<td>5 ml of plain procaine</td>
<td>None</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes</td>
<td>Entire digit</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Debeyre and Mattei, 1947</td>
<td>Ingrown nail</td>
<td>Debridement</td>
<td>3 ml of plain procaine</td>
<td>Yes, 1:160,000</td>
<td>Unknown</td>
<td>Yes, warm soaks</td>
<td>Yes</td>
<td>Epidermal slough</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Rank et al, 1968</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Entire finger</td>
<td>Photograph only; no specifics</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Bradfield, 1963</td>
<td>Infected finger</td>
<td>Incision?</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Second-hand report, poor details</td>
</tr>
<tr>
<td>45</td>
<td>Bradfield, 1963</td>
<td>Laceration and fracture of middle phalanx</td>
<td>Repair of fracture and laceration</td>
<td>15 ml of 2% procaine</td>
<td>Unknown</td>
<td>No</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Required amputation at proximal phalanx</td>
<td>Presumption of epinephrine use</td>
</tr>
<tr>
<td>46</td>
<td>Bradfield, 1963</td>
<td>Unknown</td>
<td>Unknown</td>
<td>4 ml of 0.5% procaine</td>
<td>Unknown</td>
<td>No</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Gangrene of finger</td>
<td>Presumption of epinephrine use</td>
</tr>
<tr>
<td>47</td>
<td>Sanden, 1974</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Yes</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Entire finger</td>
<td>Photograph only</td>
</tr>
<tr>
<td>48</td>
<td>Farmer, 1996</td>
<td>Unknown</td>
<td>Unknown anesthetic</td>
<td>Unknown concentration</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Unknown</td>
<td>Dermal necrosis and skin slough</td>
<td></td>
</tr>
</tbody>
</table>

I&D, incision and drainage; PIP, proximal interphalangeal; MCP, metacarpophalangeal; DIP, distal interphalangeal; IP, interphalangeal.
second edition also recommended epinephrine use in the finger. However, in the section on local anesthesia, there were multiple warnings regarding the use of epinephrine with anesthetics in the finger. In the third through sixth editions, Christopher provided discussions and citations regarding the potential dangers of using epinephrine in the digits. Ochsner and DeBakey, in 1955, were the first to warn about epinephrine injections into the ears: “Solutions containing epinephrine should not be injected into the appendages such as the fingers, toes, ears, or the penis of certain patients, notably those with peripheral vascular disease. Gangrene and slough have occurred.” They gave no specific references or examples.

Frederick Christopher’s Textbook of Surgery appeared between 1936 and 1997. The first three editions contained no specific precautions regarding the use of epinephrine in the finger. However, the fourth and fifth editions contained a warning against infiltrating too much fluid into the fingers and the dangers of epinephrine causing ischemic necrosis, without specific citations. The sixth edition in 1956 carried warnings in the sections on hand surgery and local anesthesia about local anesthetics with epinephrine, especially in infected fingers. The only specific citation for this reasoning was the article by O’Neil and Byrne, although their cases were descriptions of burns suffered under local anesthesia. The following editions did not warn about digital blocks with epinephrine.

Schwartz’s Principles of Surgery did not mention any possible dangers of using epinephrine in digital blocks until 1984. Between 1984 and 1999, the chapters on surgery of the hand cautioned that epinephrine should not be included in digital or wrist blocks due to potential irreversible vascular spasm.

The first three editions of Campbell’s Operative Orthopedics made no mention of the dangers of epinephrine use in local anesthetics. The fourth through eighth editions all stated that the use of epinephrine in digital blocks could lead to potential finger gangrene, although no specific citations were provided.

All editions of Green’s Operative Hand Surgery have cautioned against using epinephrine in digital blocks. In the current edition, Johnson’s 1967 article advocating epinephrine use in the digits is cited, in error, as a reason not to use it.

The first edition of the Physicians’ Desk Reference, which was published in 1946, contained no specific precautions regarding epinephrine in the digits. At that time, procaine with epinephrine was available in concentrations ranging from 1:20,000 to 1:100,000. The entry on Xylocaine (lidocaine), which was introduced in America in 1951, came with a warning that epinephrine should not be used for digital block anesthesia, although the same edition gave no similar precautions for procaine. In 1962, the precaution against using Xylocaine with epinephrine in digital blocks vanished. In 1973, a new warning appeared: “The use of any vasoconstrictor drug is not recommended in surgery involving the digits, nose, ear, or penis.” In 1980, this statement appeared: “Solutions containing a vasoconstrictor should be used cautiously and in carefully circumscribed quantities in areas of the body supplied by end arteries or having otherwise compromised blood supply.” This warning remains in the current edition.

**DISCUSSION**

This article reviews all 48 cases of digital gangrene and necrosis after local anesthesia in the digits (Table I). Much of the information is incomplete regarding the use and concentrations of epinephrine, hot soaks, tourniquets, tight dressings, or preexisting medical conditions. Only 21 of the 48 cases involved the use of epinephrine, and in only four is the concentration of epinephrine even known. None of the cases involved Xylocaine with epinephrine. There are no associations with Raynaud’s phenomenon, cryoglobulinemia, or sickle cell disease.

Major factors causing necrosis included the use of older anesthetics such as cocaine, Eukain, or water (seven cases). Hot soaks caused postoperative burns in 14 cases. Two cases, those of Heinicke and Hanke, involved injecting excessive amounts of anesthetic. The cases of Cutler, Rank et al., and Sandzen are photographs only. The cases of Dejardin, Chevrier, Wolfsohn, Bradfield, and Farmer provide insufficient information to allow for an analysis. Of the last 14 cases, only seven involved the use of epinephrine. Four of these 14 cases involved the use of a tourniquet; tourniquet use is unknown in the others. Eleven of
these 14 cases also involved infections. Therefore, an analysis of all documented cases of necrosis after digital blocks does not support the conclusion that epinephrine use causes the necrosis. The cases documented are too incomplete in the information outlined to make firm conclusions. Obviously, the causes are multifactorial, and not just due to epinephrine.

Five articles involving 95,54 98,56 100,65 23,66 and 200,000 patients support the premise that the use of lidocaine with epinephrine is safe in the digits and foot. The current recommendation is to avoid its use, although epinephrine has short-lived effects at extremely dilute solutions.125 A review of the history of epinephrine has short-lived effects at extremely dilute solutions.125 A review of the history of epinephrine's use shows that it does not deserve its dangerous reputation. All techniques are fraught with potential complications.

The recommendations to take away from this study include the following:

1. Small amounts of local anesthetics with dilute epinephrine are probably safe for digital infiltration or blocks.
2. Use dilute solutions such as 1:200,000 or less.
3. Do not do a circumferential block of the digits.
4. Block preferentially at the level of the metacarpal heads rather than the digit.
5. Use small needles to avoid injuring the vessels.
6. Avoid postoperative hot soaks.
7. Buffer the anesthetic to avoid acidic solutions.
8. Bandages should not be constrictive or excessively tight.
9. Patients should be followed regarding prolonged ischemia, which could require reversal with phentolamine injections or nitroglycerin ointment.
10. Avoid using epinephrine in patients with vasospastic, thrombotic, or extreme medical conditions.
11. If you know of specific complications, report them and the details.

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REFERENCES


38. Riccio, R., and La Rossa, F. The alleged inconveniences of local anaesthesia with Novocaïne. II: 175, 1925.


