

with their interventional radiologist regarding the type of sclerosing agent that will be used and appreciate the potential dangers of using cautery during resection of lesions embolized with Onyx.

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### DISCLOSURE

*The authors have no financial interest to declare in relation to the content of this article.*

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### Antibacterial Analysis of Surgical Adhesives

Sir:

**S**urgical-site infections account for approximately 300,000 nosocomial infections in the United States annually, of which approximately 20 to 30 percent are caused by *Staphylococcus aureus*.<sup>1</sup> Prevention of surgical-site infections is of paramount concern to the surgeon.

There is debate as to the advantages of the commonly used surgical adhesives Mastisol (Ferndale Laboratories, Inc., Ferndale, Mich.) and compound tincture of benzoin (3M, St. Paul, Minn.). Compound tincture of benzoin may cause allergic contact derma-

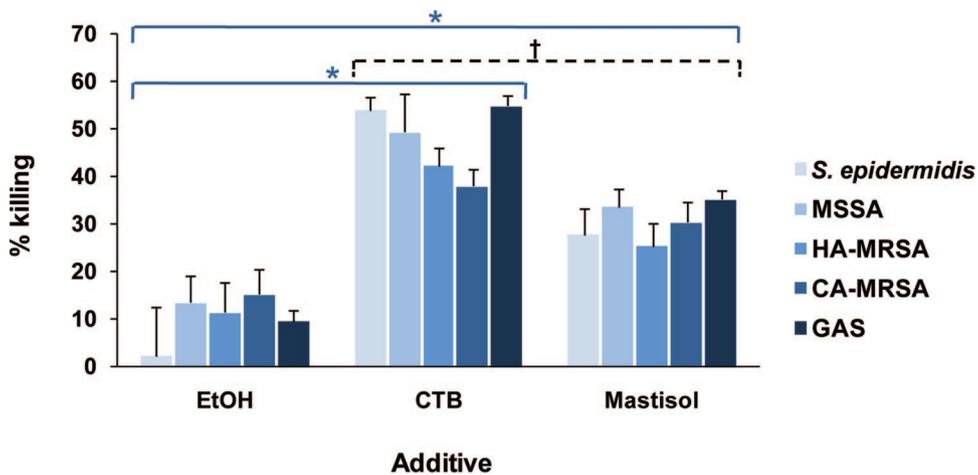
titis and sensitization against other adhesives.<sup>2</sup> Mastisol has greater adhesive strength,<sup>3</sup> suggesting that it may be superior. There are no published studies of the antimicrobial effects of Mastisol, and there are only limited evaluations of compound tincture of benzoin.<sup>4</sup> We hypothesized that Mastisol and compound tincture of benzoin would kill common clinical isolates that cause surgical-site infections.<sup>5</sup>

In a variation of Nathan's method,<sup>6</sup> 90  $\mu$ l of bacteria was mixed with 10  $\mu$ l of 100% ethanol, Mastisol, compound tincture of benzoin, or a buffered salt solution. Both adhesives polymerized rapidly, forming a granular sediment that was vortexed with the bacteria for homogeneity. The mixtures were incubated for 4 minutes, diluted, spread on agar plates, and incubated overnight. Percentage killing was calculated by enumeration of colony-forming units compared with that obtained in buffer.

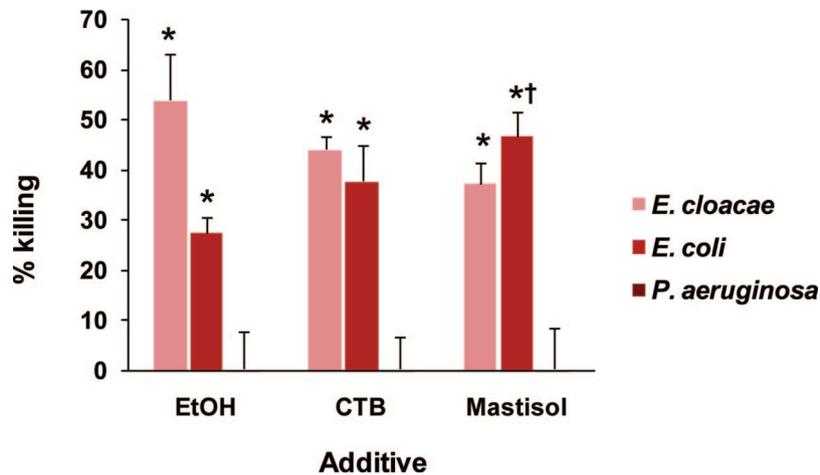
We found that compound tincture of benzoin mediated significant ( $p \leq 0.01$ ) killing of 38 to 55 percent of Gram-positive bacteria, whereas Mastisol killed 25 to 35 percent (Fig. 1). Compound tincture of benzoin-mediated killing exceeded that of Mastisol ( $p < 0.05$ ) against all Gram-positive bacteria except community-associated methicillin-resistant *S. aureus*. We also found 38 to 47 percent killing of the Gram-negative bacteria *Escherichia coli* and *Escherichia cloacae* (Fig. 2) ( $p < 0.01$ ). There was no difference in killing of these Gram-negative bacteria by either adhesive, and there was no killing of *Pseudomonas aeruginosa*.

In summary, we show that compound tincture of benzoin and Mastisol manifest antibacterial activity against surgical-site infection-related pathogens, including methicillin-resistant *S. aureus*. The mechanism(s) of killing may include the antimicrobial effect of ethanol, other ingredients, and/or polymerization. Compound tincture of benzoin contains approximately 75 to 83% ethanol, an effective antimicrobial. Because Mastisol is proprietary, its ethanol content is unknown. In the current work, the relative contribution of polymerization to the overall antibacterial effect cannot be assessed because the bacteria had contact time with the adhesives in both liquid and polymerized forms.

It has been suggested by others that the outer membrane of Gram-negative bacteria and/or lipopolysaccharide confers resistance to the antimicrobial effect of polymerization.<sup>7,8</sup> However, our finding that two Gram-negative bacteria, *E. coli* and *Enterobacter*, were killed by compound tincture of benzoin and Mastisol to similar extents as Gram-positive bacteria makes this explanation unlikely. However, our work does raise the question of why *Pseudomonas* was resistant to killing, as observed by others.<sup>7,8</sup> Although the outer membrane of *Pseudomonas* differs from that of Enterobacteriaceae, as it expresses a different lipopolysaccharide, numerous efflux pumps, and modulated porin expression, whether these factors contributed to resistance to ad-



**Fig. 1.** Killing of Gram-positive organisms. The indicated strains were incubated with ethanol, compound tincture of benzoin, or Mastisol. Statistically significant killing of all Gram-positive strains by ethanol, compound tincture of benzoin, and Mastisol versus buffer was observed ( $p \leq 0.01$ ). Both adhesives showed superior killing of all strains versus ethanol (solid blue brackets,  $*p < 0.05$ ). Except for community-associated methicillin-resistant *S. aureus*, greater killing of the strains by compound tincture of benzoin versus Mastisol was observed (dashed black bracket,  $\dagger p < 0.05$ ). Data are the mean  $\pm$  SEM of at least three experiments in triplicate, and significance was determined by the using the *t* test. MSSA, methicillin-sensitive *S. aureus*; HA, hospital-associated; CA, community-associated; GAS, xxx; CTB, compound tincture of benzoin.



**Fig. 2.** Killing of Gram-negative organisms. The experiment was performed as in Figure 1. Statistically significant killing of *E. cloacae* and *E. coli* by ethanol (EtOH), compound tincture of benzoin (CTB), and Mastisol versus buffer was observed ( $*p < 0.01$ ), but the viability of *P. aeruginosa* was unaffected. No significant difference in killing of *E. cloacae* and *E. coli* between the two adhesives was observed, and only Mastisol-mediated killing of *E. coli* was significantly greater than that mediated by ethanol ( $\dagger p < 0.01$  versus ethanol).

hesive-mediated killing is unclear and requires further study.

The rapid onset of the antimicrobial effect of compound tincture of benzoin and Mastisol is notable because this short time frame is unlikely to select for resistance. Given the worrisome spread of multidrug-

resistant bacteria, this is a desirable property. Finally, this work raises the question about whether antibiotic ointments are useful postoperatively if compound tincture of benzoin or Mastisol are used. Future animal studies are necessary to address this important question.

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**DISCLOSURE**

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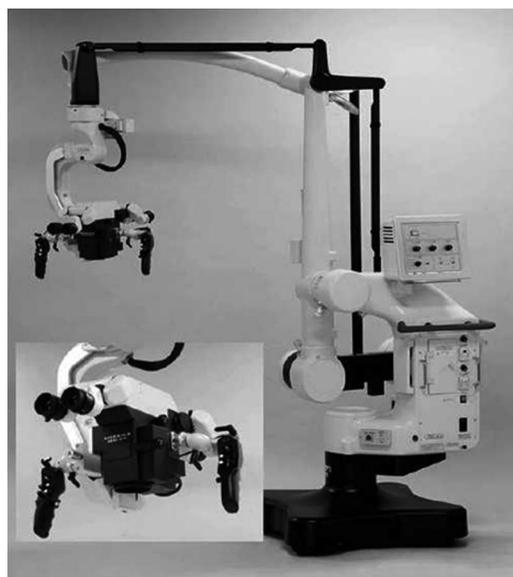
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**Instruments for Supermicrosurgery in Japan**

*Sir:*

**S**upermicrosurgery techniques for anastomosis of blood vessels thinner than 1 mm (0.3 to 0.8 mm) have recently been developed.<sup>1,2</sup> This technique has allowed development of many new therapeutic methods, including surgery using a perforator flap,<sup>3</sup> re-plantation of amputated fingertips,<sup>4</sup> and lymphaticovenular anastomosis.<sup>5</sup> These instruments include a surgical microscope with the highest currently available magnifying power, with 50× magnification (MM50; Mitaka Kohki Co. Ltd., Tokyo, Japan) (Fig. 1), the thinnest titanium forceps in the world (Togari; EMI Factory Co., Nagano, Japan) (Fig. 2), the world's smallest surgical needle (12-0 nylon; Crownjun Kono Co., Tokyo, Japan) (Fig. 2). These instruments allow supermicrosurgery on vessels of 0.3 to 0.8 mm and have opened new frontiers of vascular surgery.

The patient was a 74-year-old woman who underwent mastectomy and axillary lymph node dissection for right breast cancer. Under local anesthesia, three lymphaticovenular anastomoses were made. In the wrist, a 0.4-mm lymphatic vessel and a 0.5-mm vein were anastomosed in end-to-end fashion using 12-0



**Fig. 1.** A surgical microscope with a magnifying power of 50×, which is the highest available in the world.