

**R**alph Waters (1883-1979) and Arthur Guedel (1883-1956) were major leaders in the development of modern American anesthesiology. Their extensive correspondence documents a wonderful collaboration while they worked on the problems of anesthesia of that time. This could be because they shared similar

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### TWO MEN AND THEIR DOG: RALPH WATERS, ARTHUR GUEDEL AND THE DUNKED DOG "AIRWAY"

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environments as they grew up and because they grew up at the same time (they were born the same year). Waters was born on a farm in Ohio. Guedel was born in Indianapolis, a city still considered "partly rural" by the U.S. Census Bureau as late as 1970.<sup>1</sup> These locations, only about 250 miles apart, were in the heart of America, the Midwest. The strong values and culture of early twentieth century America were integral parts of their lives. These values were to be important factors as they worked to develop the relatively primitive field of anesthesia into a science-based medical specialty.

In addition to the values and the culture of the time, they also shared a dog, "Airway," at one point in their lives. Pet dogs were then, and still are, an important part of American culture and values, and each of the men had deep affection for dogs (fig. 1). Their correspondence often contained references to their dogs, especially Airway. Originally the Guedel family's pet, Airway was used to illustrate the advantages of anesthesia with a cuffed endotracheal tube in the "dunked dog" experiment. This experiment seems to be well known, no doubt because it was so striking. But, the history behind it has not been well documented. This paper reviews what is known from documentary sources about the

dunked dog experiment and describes the affection both men felt for the dog. It also briefly considers why they might have chosen to use a much-loved pet for this experiment. Sources for this paper were the Guedel-Waters correspondence at the Guedel Center, documents in the Waters' Collection at the Wood Library-Museum, and primary and secondary articles in medical literature.

Airway arrived at the Guedel family, which already had two dogs, by 1928. It is not known how he got to the family. The Guedels were in Indianapolis at the time, where Guedel practiced at St. Vincent's Hospital and taught anesthesia at the University of Indiana Medical School.<sup>2</sup> In 1928 Ralph Waters had been at the University of Wisconsin for a year as chief of a new division of anesthesia. The two met at anesthesia meetings in the Midwest. In 1923, at the fall meeting of the Congress of Anesthetists, Waters had presented a clinical system for CO<sub>2</sub> removal. This improved on Dennis Jackson's liquid-based system, by using solid soda lime in a valveless to-and-fro system.<sup>3</sup> This technique was published in 1924<sup>4</sup> and further refined in a paper in 1926.<sup>5</sup> Although a desirable technique physiologically, the heavy metal container for the soda lime, a very large reservoir bag, and the need to continually hold a mask (endotracheal tubes

were only rarely used) made for an awkward clinical situation.<sup>6</sup>

At the same time, Guedel was working on developing cuffed endotracheal tubes. (The earlier use of cuffed tubes was not known to either Guedel or Waters at the time they started working on them.) After his anesthetic experience in WWI, Guedel realized the need for better airway control and began work on this problem. He set up a basement lab in his Indianapolis home and studied the anatomy of the airway, using lamb tracheas that Mrs. Guedel purchased for him at the local butcher shop, and tried to develop various methods to seal off the trachea. He was also trying out Waters' CO<sub>2</sub> absorption technique, using the Foregger "midget" machine.<sup>7</sup>

Endotracheal anesthesia at that time was "insufflation," in which large amounts of gas were delivered to the trachea (a metal, woven silver or rubber catheter—without a cuff or seal—might be placed in the trachea) or nearby (in the case of an ether hook for oral surgery). Patients breathed spontaneously and CO<sub>2</sub> would hopefully be removed in the excess gases leaving the trachea or mouth. It was immediately apparent to Guedel that insufflation would not work with the "midget" apparatus because of the small amount of gases available.<sup>7</sup> (Midgets at that time used small A tanks.) Later, midget machines could be mounted on a stand and standard E tanks, with larger gas volumes, could be used.<sup>8</sup> This issue took on even more importance because Guedel was considering moving to California. He knew that he would have to go hospital to hospital there, taking his machine with him. There needed to be a way to conserve anesthetic gases in a "closed" system for the midget machine, as opposed to the usual "open" system, insufflation. In a closed anesthesia system, CO<sub>2</sub> would have to be removed, so he needed Waters' absorption technique using the metal Waters to-and-fro canister. Somehow he came to the idea of sealing off the airway with a cuffed tube, keeping

all gases within the trachea. This would solve multiple problems of the time: It would avoid the waste of insufflation technique, it would solve the awkwardness of holding a mask and dealing with the heavy Waters canister (it was usually supported on a pillow<sup>6</sup>) and the system could protect the lungs from aspiration of blood, gastric contents, or pus. Guedel was familiar with the risk of aspiration from his wartime work.

Guedel's first cuff was made from fingers of rubber gloves, then a rubber condom whose ends were cemented

around the endotracheal tube. (Note: Guedel gives varying information on this, in one case stating the condom was used first.) The first cuff was between three and four inches long and was designed to lie half above and half below the glottis. Deep anesthesia was required for this cuff to stay in place; laryngeal reflexes would have to be obliterated. And, if the patient should cough or swallow, the tube could come out into the oropharynx. Next, Guedel made cuffs from a rubber dental dam. This was 1-1/2 inches long and was designed so the upper edge would be just below the vocal cords. This became known as a "flat" type cuff and is the one pictured in Waters and Guedel's paper on cuffed endotracheal tubes.<sup>7</sup>

By April 1928, Guedel was giving anesthesia with a "cuffed" tube. In fact, he did patients first and dogs afterwards! He reported to Waters filling up an intubated patient's oropharynx with water to demonstrate there were no leaks:

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You should have been here today. Handed a woman closed intratracheal ethylene with ether adjuvant for laparotomy for hour and a half. Incidentally we filled her mouth and nose full of nice clear water and left it there for fifteen mins or so...you should have seen her there, flat on her back—about eight degrees Trendelenburg—carrying her water brim-full and without a gargle. Now you tell one.<sup>9</sup>

He practiced dunking two intubated dogs in early April 1928, and then had the idea of anesthetizing a dog, intubating with a cuffed tube and putting the dog under water, to illustrate the advantages of cuffed tubes and the CO<sub>2</sub> absorption system to others. He suggested this to Waters in a letter on April 7, 1928.<sup>10</sup> Waters wrote back, "Your suggestion of the dog under water is a good one, but it's not new. [Waters offered no information on who had done this before.] However, done with to-and-fro breathing and no bubbles it would be new and if I can find a student that isn't too busy, we'll show it to you in June."<sup>11</sup> Guedel wanted to embellish the show, writing back, "For the show I would prefer a pink aquarium with goldfish and some nice shells."<sup>12</sup>

The "dunked dog" experiment actually took place in Indianapolis, not Madison, and was done by Guedel, not Waters. The event was at the Indiana University School of Medicine. The probable date was May 8, 1928. The subject was convenient, the pet dog, Airway. Anesthesia for the dog was morphine followed by ethylene and intubation with a cuffed tube. After an hour of submersion in an aquarium, anesthesia was stopped, and the dog sat up in the tank. After being placed on the floor, he shook himself off and laid down for a nap. Attending the demonstration were Waters (who had not yet seen the closed endotracheal technique) and Guedel, two other physicians and medical students. Guedel and Waters' paper on cuffed tracheal tubes was published in

July-August 1928 and described the "dunked dog" experiment.<sup>13</sup> It was not possible to find any other descriptions of this experiment or a similar one in the medical literature.

Guedel and Waters had discussions about repeating the experiment at anesthesia meetings, to teach others about the new technique of CO<sub>2</sub> absorption and cuffed endotracheal tubes. There was at least one other demonstration, but it is not certain at what event it took place. Waters wrote it was for a Student Day at the University of Wisconsin in June 1928.<sup>14</sup> Guedel wrote of a demonstration at the meeting of Anesthetists in June 1928 at the University of Wisconsin, at an American Medical Association meeting.<sup>7</sup> No records exist to clarify this situation. This second event we know was staged by Waters and Guedel together and proceeded, as did the one at the University of Indiana, except this time the dog was under water for four hours. This dog was one used for lab experiments, not a family pet. The dog died the next morning, most likely of pneumonitis.<sup>14</sup>

Waters took a picture of this second experiment and it was published in a popular book, *Man Against Pain: The Epic of Anesthesia*, published in 1945.<sup>15,16</sup> A second popular book on the history of anesthesia published about the same time also mentioned the experiment but had no picture.<sup>17</sup> These books could be the sources of common knowledge of the "dunked dog" experiment. The experiment is also mentioned by Chauncey Leake in his introduction to Tom Keys' *History of Surgical Anesthesia*. Leake credits Waters with the experiment.<sup>18</sup> Leake, professor of Pharmacology at the University of Wisconsin in 1928, had been present at the second experiment and no doubt ignored Guedel and his role, due to Leake's Wisconsin ties.<sup>15</sup> Leake's piece was written well after the event, and it is possible his memories were not correct.

What happened to Airway after the experiment? He was the third dog in the Guedel

family, which was about to move to California. (It is not known what happened to the other two dogs on the move, but Guedel had at least one dog in California, a dog who ate the garden's snails.) Guedel offered him to Waters, describing him fondly: "He has a kind face and silky ears. More ears than face...His kind face and the fact that he took a bone away from a bigger and even dirtier dog, won me over."<sup>19</sup> Mrs. Waters agreed to accept another dog into the busy Waters household. Guedel planned at first to drive Airway up to the Waters house, but had to ship the dog by rail due to lack of time. "Dog is being sent by express co...we estimated he was worth a dollar or so. I think he will hunt rabbits and maybe cats...Love and regards to the dog...I am sending him to your labs and if you want to take him from the lab that is your responsibility."<sup>20</sup> Waters wanted Airway as a pet for his sons, Darwin and John.<sup>14</sup>

When Airway arrived in Madison, Waters wrote: "Airway is a fine scroot. He is, however, just a bit too tony for my family. I think he was brought up in a limousine. He has a private limousine and chauffeur and he would prefer to ride all the time. He was so insistent on going with me Saturday that I had to punish him severely."<sup>21</sup> Subsequent letters between Waters and Guedel often contain information on the

dog. Guedel would inquire about him; it was clear he missed Airway and enjoyed hearing about him. Waters would report the dog's adventures in Madison or Door County where the Waters vacationed. After nearly two years with the Waters family, Airway vanished: "Airway is aus gespielt. I think someone stole him."<sup>21</sup>

What might have led them to anesthetize this loved pet and use it for the "dunked dog" experiment? First, he was easily available. And, research standards of the time were much more casual than. Physicians were often experimenting on themselves, and dogs were often used in labs. Experiments were viewed as low-risk events, even if they were not. Finally, dogs were seen as expendable. So what might be seen as animal abuse today was within the standards of the time.

The "dunked dog" experiment introduced the CO<sub>2</sub> absorption technique and cuffed endotracheal tubes to a large audience, even though only a few physicians attended the actual demonstrations. Waters' papers on CO<sub>2</sub> absorption and Waters and Guedel's paper on cuffed endotracheal tubes were other ways these techniques were popularized. These techniques form the basis of modern anesthesia practice. Guedel, Waters—and Airway—deserve a great deal of credit for their parts in developing and introducing these techniques.