HISTORY OF SURGICAL FACE MASKS

John L. Spooner

The myths, the masks, and the men and women behind them

It is difficult to determine exactly when face masks were first used to help control surgical sepsis. In 1897 Johann von Mikulicz Radecki[1] described a surgical mask composed of one layer of gauze. That same year Fluegge[2] demonstrated that ordinary conversation could disseminate bacteria-laden droplets from the nose and mouth, substantiating the need for an effective face mask. This marked the realization of the danger of human exhalation as a cause of surgical wound sepsis.

In 1898 Huebner[3] recommended that masks made of two layers of gauze, worn at a distance from the nose, be used during operations. He showed that mask efficiency was improved by increasing the layers of gauze and that masks worn close to the nose collected moisture and decreased in efficiency. In 1905 Hamilton[4] proposed that scarlet fever was transmitted through droplet infection. She recommended that masks be worn by nurses handling sterile dressings and by doctors during surgery because of the danger of droplet infection from the mouth and nose. Lord Moynihan[5] in 1906 also advocated use of masks during operations.

During the next few years, various investigators confirmed the value of face masks in protecting the wearer against infection. In 1915 Meltzer[6] advised that masks of fine mesh gauze be used to cover the faces of patients with infantile paralysis and the faces of personnel attending them. In 1918 Weaver[7] reported that over a two-year period the incidence of diphtheria contracted by attendants of infected patients was reduced to zero after wearing masks of double thickness gauze. It is interesting to note that he recommended sterilization of masks after each use, and replacing a mask with a sterile one when it became moist, and that he cautioned against hands being placed on the mask.

In that same year, Capps[8] followed the procedure of Weaver and confirmed the efficacy of face masks in military hospitals for protecting personnel attending patients with contagious diseases, as well as for protecting patients against cross-infection. Capps

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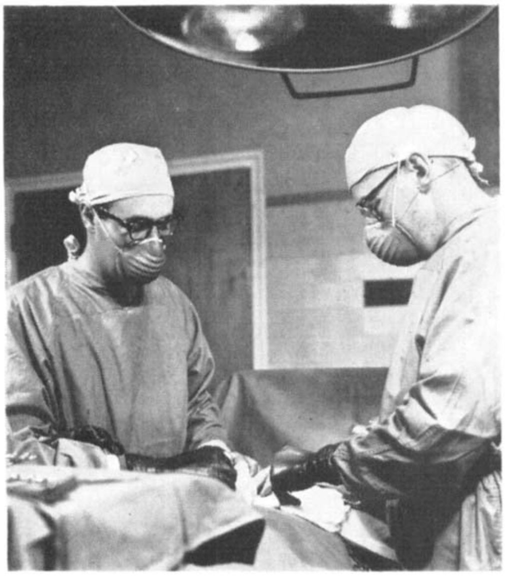

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used a gauze mask of three to four layers, 5″x7″ in size.

At about this same time, various investigators were attempting to determine which type of gauze mask was most effective. The first report on the relative effectiveness of various gauze masks appeared in 1918, shortly after Capps presented his findings. Doust and Lyon[9] tested three types of masks: coarse gauze, medium gauze, and "butter cloth." Each mask was 6″x8″ with hemmed edges, had four-cornered ties, covered from below the chin to above the nose, and varied from two to 10 layers in thickness. They concluded that the coarse gauze was inefficient regardless of the thickness, and that a finer gauze was more efficient.

In 1919 Weaver[10] and Leete[11] confirmed the findings of Doust and Lyon. Weaver found that mask efficiency was in direct ratio with the closeness of the mesh and the number of thicknesses of gauze. He recommended a fine mesh gauze with 44x40 threads to the inch. Leete further confirmed that a wet mask is completely inefficient and also recommended that masks be changed when worn for any length of time.

By the late 1920's, the use of gauze face masks was widespread. Additional data confirming the value of face masks in preventing infection of surgical wounds were published by Walker in 1930, by Meleney in 1935, and by Hart and Davis[12] in 1937. Davis also confirmed that wearing masks over the mouth only is entirely inadequate and that the longer the operation, the greater the risk of contamination.

In the 1930's variations of the gauze type masks began to appear. Walker proposed that a six-inch piece of rubber be placed between two layers of gauze to create a "germproof" mask. Mellinger[13] designed a mask consisting of a 14 karat gold-filled wire frame, covered with waxed paper on both sides, and extending to below the chin. Kaplan[14] designed a similar mask, using washed X-ray film as the deflector material. Blatt and Dale[15] reported that the ordinary gauze mask was both uncomfortable and bacteriologically ineffective compared to their more comfortable, highly effective cellophane, gauze deflection mask. Some of the other deflector-type masks reported on during this period included: the "Jel" mask which was a combination of gauze and filter; a mask with a cellulose derivative, plastacele, and including cotton pledgets; a flannel mask which was a layer of Alaska flannel placed between two layers of 44x40 mesh gauze; and a paper mask consisting of a paper napkin, two small paper clips or safety pins, and two rubber bands.

In 1938 McKhan, Steeger and Long compared the efficiency of gauze masks and deflector-type masks currently in use, and also reported on two new masks.[16] The four masks tested were: 1) absorbing gauze mask; 2) impervious mask which deflected expelled air behind the mask wearer; 3) paper masks; 4) filter mask in which a compressed layer of cotton was placed between layers of absorbing gauze. The filter type of mask proved to be the most effective of all, effective for a longer period, and effective after repeated washings.

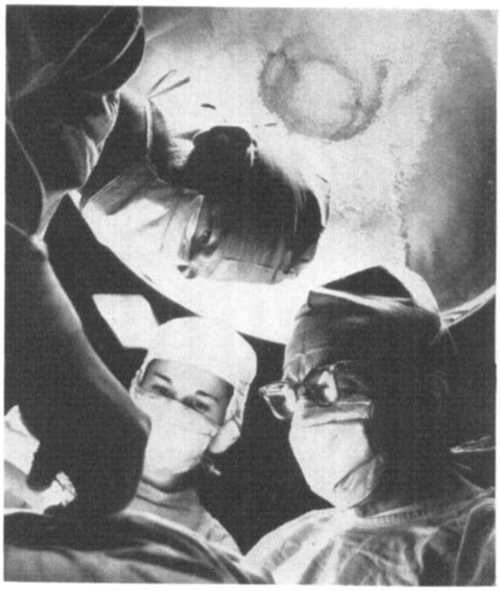
With the introduction of antibiotics in the 1940's, and their rapid acceptance as a means of controlling infection, interest in surgical masks decreased. There were no new developments and no papers of significance were published. However, as the years went by and clinical data accumulated, it became apparent that the "wonder drugs" were no substitute for meticulous attention to aseptic surgery techniques.

In the late 50s there was renewed interest in surgical masks that would effectively protect the patient's open wound from the discharge of pathogens from the mouth and nose of operating room personnel. Aseptic surgical technique now included the surgical scrub, rubber gloves, capping and gowning, and sterile drapes. Airborne bacteria remained as one of the significant factors influencing the rate of surgical wound sepsis.

In 1958 Kiser and Hitchcock reported on a mask that combined the deflection and filtration principles.[17] This was a plastic mask that diverted the flow of breath backward on either side. Filter material near the side outlets was designed to trap the deflected organisms. The next year Adams[18] evaluated a fitted filter mask and found it more efficient than gauze masks. In 1960 Rockwood and O'Donoghue[19] judged that the length of time a filter mask retains its efficiency was three hours; confirmed the inefficiency of absorbing gauze masks; and stressed the fact that the proper use of the best mask available could prevent infection.

In 1961 Musselman[20] reported on a new fitted mask designed to be used only once and then discarded. The mask incorporated a filter in a plastic shell that was shaped to fit the face. An elastic band secured it in place. Excellent bacterial filtration was reported.

A great deal of work has been done to



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evaluate the efficiency of face masks. Studies by numerous investigators confirm that gauze masks are of negligible efficiency, multiple layers must be used, coarse and medium mesh are completely inadequate, dampening further decreased efficiency, improper fitting permitted bacteria to escape from beneath the sides of the masks, and that they were most uncomfortable to wear.

In general, deflector-type masks are reported as inadequate because they only prevent the exhalation of bacteria directly in front of the wearer's mouth. The number of colonies of bacteria throughout the room remain the same regardless of whether or not a mask is worn.

Rockwood and O'Donoghue and Adams et al best summarize the inefficiency of gauze masks for protecting the patient or his open wound against germs exhaled by operating room personnel. "For many years, the traditional gauze mask has been worn in recognition of this problem and as one attempt at solution. Unfortunately, gauze masks are of negligible efficiency. . . . There is a discernible barrier effect directly in front of a dry gauze mask and, more noticeably, in front of doubled dry gauze masks for short periods of time after they are put on. This protective effect diminishes rapidly as the mask becomes moist, is related to the amount of talking or forcefulness of breathing, and is down to less than 10 per cent efficiency after ten minutes if the wearer is also talking. However, there is a billowing-out effect around the sides of these masks from the beginning of wearing, no matter how carefully they are applied."[21] "Maximum mask efficiency is dependent upon an adequate peripheral fit as well as efficient filter material."[22] A mask with high filtration efficiency must make tight and non-leaking contact with the skin of the wearer to be of clinical value. When masks do not fit properly, or billow out, "one can gather large numbers of bacterial colonies from air emerging beneath the sides of these masks from the moment they are put on."

"The filter-type mask is the most efficient and to wear a mask of absorbing gauze, especially of wide, coarse gauze, means poor protection to the patient. Many hospitals are using and buying improper masks. Since we have standards of sterile techniques in hospitals, it would be of benefit to the hospitals to have a standard setup for masks, in order that absorbing masks of coarse gauze and improper thread count are not used."[23]

As noted above, the ability of a surgical mask to filter efficiently also involves the length of time it can maintain that efficiency. Even earlier investigators recognized that a wet mask becomes completely inefficient, and rcommended that all masks be changd after being worn for any length of time. The adverse effect of moisture and of prolonged wearing periods on the efficiency of many masks has also been emphasized by others.

Today the importance of face masks to help prevent surgical wound infection is universally accepted. Adams et al believed that "Air contamination of a room by human exhalation is at least 98 per cent preventable and controllable by proper filter masking of all people entering the room." New and improved methods for evaluating the effectiveness of face masks play an important role by helping determine the best possible mask available.

Most evaluation methods utilized agar plates, petri dishes, or glass slides exposed at various distances to the source of droplets to catch and determine contaminated particles. In 1942 Jennison attempted to measure orally expelled contaminents by means of high-speed photography.[24] Musselman also employed high-speed photography and stroboscopic lighting in a sneeze test to demonstrate the superior performance of a fitted filter mask compared to gauze masks. Hirshfield and Laube[25] developed an experimental chamber designed to achieve controlled environmental and quantitative sampling of bacterial contaminents. In 1958 Andersen[26] developed a sampling chamber to collect airborne particles in several categories of decreasing particle size. More recently Green and Vesley[27] pointed out that "Critical studies of mask efficiency which employed artificial aerosols yielded valuable information about the filtering capacity of masks, but did not simulate the normal orally expelled microflora and the saliva droplets in which they are incorporated. Consequently, most of the mask efficiency ratings which are available in the literature are not directly related to actual practical conditions." They recommend a mask evaluation method that would provide "information which is both volumetric in nature and which approximates the actual conditions under which a mask is worn."

During the last decade growing concern with postoperative infections has intensified interest in masking. The incidence of surgical wound infections in hospitals is reported to have risen appreciably." New surgical procedures that permit operations of greater magnitude, duration and trauma increase the potential for such infections. It has been stated that "every major infection costs someone $3,000. An infection rate of 50 per 1,000 or 5 per cent, which equals $150,000 per 1,000 cases, has been reported in some series."[28]

A 5 per cent rate of infection, projected against a base of 25 million surgical procedures in the United States annually, totals an estimated 1.25 million cases, at a calculated cost of over $3 billion.

"One should also consider such factors as morbidity and mortality, costly and prolonged hospitalization, additional and complicated treatment and loss of time and money. Infections slow bed turnover in overcrowded hospitals, and compensation claims raising the question of potential liability of the hospital and the physician, are a frequent sequel."[29]

Every effort to strengthen the links of aseptic technique should be made. Even a one per cent reduction in the rate of infection reduces the estimated U.S. total by 250,000 cases; ten per 1000; one per 100 procedures.

With new medical care programs bringing a further increase in the number of patients over the age of 65, operations of greater magnitude and duration, a shortage of nursing personnel, and increasing costs of patient care and bed space, the contribution of an efficient surgical mask to help prevent wound infections is of importance. It is the perpetual responsibility of both manufacturers and the medical community to evaluate new materials, products and procedures which can make possible a reduction in the rate of infection.

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