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USAARL REPORT NO. 73-9

A COMPARISON OF METHODS OF PREPARING PORCINE SKIN FOR BIOASSAY OF THERMAL INJURY

By

Thomas L. Wachtel, M.D.
CPT G. R. McCahan, Jr., DVM

March 1973

U. S. ARMY AEROMEDICAL RESEARCH LABORATORY

Fort Rucker, Alabama 36360

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U. S. Army Medical Research and Development Command

The Vivarium of the United States Army Aeromedical Research Laboratory is fully accredited by the American Association for Accreditation of Laboratory Animal Care.

In conducting this research, the investigators adhered to the "Guide for Laboratory Animals Facilities and Care" prepared by the Committee on the Guide for Laboratory Animals Facilities and Care, National Academy of Sciences, National Research Council. Humane procedures were utilized throughout, and a graduate veterinarian was in constant attendance to perform all surgical procedures and to ensure that all animals were fully anesthetized and insensitive to pain.

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ABSTRACT

Clipping, shaving, and depilation methods of hair removal were evaluated on porcine skin in preparation for its use as a bioassay substrate for thermal injury. Each method provides distinct advantages and disadvantages. Criteria for selecting the proper methodology are identified for a bioassay substrate for thermal injury studies.

APPROVED: ROBERT W. BAILEY
Colonel, MSC
Commanding

A COMPARISON OF METHODS OF PREPARING PORCINE SKIN FOR BIOASSAY OF THERMAL INJURY

INTRODUCTION

Skin preparation (hair removal) is an important factor in preoperative management[1] and is required for porcine skin to be anatomically similar to human skin.[2] Preoperative shaving has been the traditional method of hair removal in preparing the body surfaces of human beings for surgery.[3] Depilatory hair removal is considered a good or superior alternative method.[1,3-11] Clipping hair with a #40 clipper head has been considered the standard for animals, although published data to support this method are not available.

Clinical and field experience from informal experiments and from trial and error forms the major source of information for using clipping in animals rather than other methods. Objections have been raised over the hair stubble which inevitably is present following careful clipping. In addition to the fact that hair in the operative field is to be abhorred, using the skin of pigs as a substrate for the bioassay of thermal injury requires that this stubble not interfere with thermal transfer by shading the skin from radiant or convective heat nor act as a scaffold to elevate a test fabric sample enough to provide a thermal insulating air gap. These factors must be evaluated against the inevitable irritation and microscopic injuries of shaving[3] and the time consuming and costly process with depilatory agents.[5]

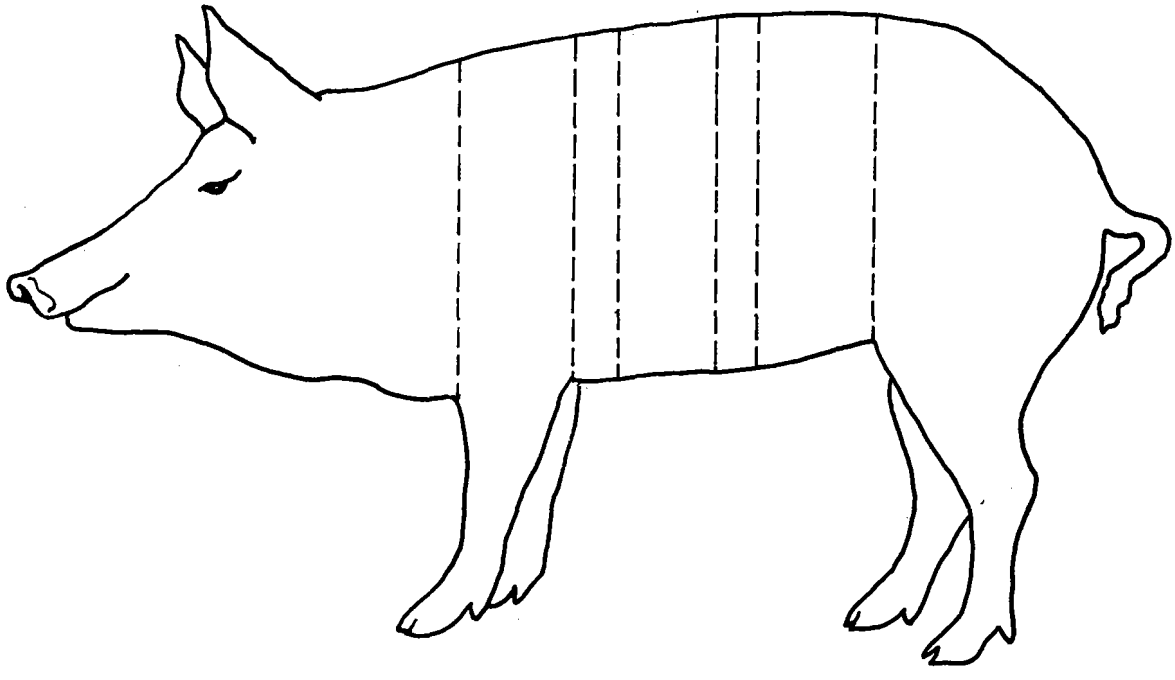
It is in light of these questions that the following studies were undertaken prior to further studies using porcine skin for bioassay of thermal injury.

METHODS AND MATERIALS

Three white female domestic (35.9-37.2 kg) swine (Sus scrofa domesticus) were used for this study. They were locally procured, quarantined, and verified to be healthy and free of internal parasites prior to their use in this experiment. Their entire skin was clear and free of any lesions (insect bites, scratches, nicks, excoriation, irritation, dermatitis, etc.).

Following an overnight fast, each animal was premedicated with atropine

(0.02 mg/lb) and Innovar-Vet* (1 mg/20 lb), intubated, and anesthetized with Halothane, USP.[12] Both sides of the animal were clipped with a #40 clipper head. Three 3x10 inch test areas (long axis vertical) separated by one inch buffer areas were selected on each side and marked off (Figure 1). The sequence of test procedures for each of the six flanks used was randomly selected.



TEST AREA CONFIGURATION

FIGURE 1

*McNeil Laboratories, Ft. Washington, PA 19304

The test procedures included preparation by one of three means:

1. Clipping wth a #40 clipper head (previously done to entire side).

2. Skillful wet shaving with a straight razor.

3. Depilation with calcium thioglycollate cream* applied in an even thick layer against the direction of the hair growth, allowed to remain for fifteen (15) minutes, removed with a tongue depressor blade, and then cleansed with soap and water (per manufacturer's recommendation).

The following separate sequences were possible:

Clipping - Depilation - Shaving
Clipping - Shaving - Depilation
Depilation - Shaving - Clipping
Shaving - Clipping - Depilation
Shaving - Depilation - Clipping

No allowance was made for individual side variations (i.e., cephalocaudal).

The areas were each evaluated immediately after hair removal and at days three, five, and ten in the following manner:

1. Close-up photographs were taken.

2. Clinical:

   a. Each area was inspected for such things as normal skin, erythema, excoriation, rash, flaking, scratches, nicks, edema, inflammation, infection, etc.

   b. Hair stubble length was measured carefully.

---

*Surgex, Chemway Corporation, Wayne, NJ 07470. Distributed by CIBA Pharmaceutical Company, CIBA Corporaton, Summit, NJ 07901.

An average hair population count and average hair diameter determination was accomplished by clipping and carefully retrieving all the hairs from measured areas that represented those areas that could be used in thermal bioassay analyses.

RESULTS

Clipping was fast and normally required less than five minutes for two technicians to clip each pig. It was possible to clip an animal without anesthesia but the results were so uneven as to be unsatisfactory. It caused no irritation or other trauma to the skin. Hair stubble was visible on the immediate post procedure evaluation and measured 1.5 to 2.0 mm in length. It had grown to 2 to 3 mm by the third day, 3 to 4 mm on the fifth day, and 5 to 6 mm on the tenth day.

The usual time required to carefully shave each side of the animal was approximately fifteen minutes and two or more new razor blades were used for each side. Shaving often caused "scrapes," abrasions, scratches, erythema, or excoriation (Figure 2) which healed by the tenth day post shaving. Hair stubble could not be seen immediately after the procedure but it could be felt when brushed against the grain, especially along the back of the animal. It had increased in length to 1.0 to 1.5 mm on day three, 1.5 to 2.5 mm on day five, and 3 to 4 mm on day ten.

Depilation required at least fifteen to twenty minutes to prepare each side. A thick coat of Surgex, applied as directed, covered approximately 30 to 50 square inches of surface per 100 gm. The cost to the U.S. Army was $1.29 per 100 gm. The depilatory technic caused transient erythema, but no other forms of trauma on initial evaluation. The skin was smooth and free of debris. The hair stubble was not visible but could be palpated against the grain and grew at exactly the same rate as that after shaving.

There were 14.31 ± 5.29 s.d. hairs per square centimeter of skin surface with a variation occurring depending upon anatomical locale. The average diameter of the hair was 0.875 mm. This provided a maximum shading factor from the hair of 7.89 to 17.15% (if hair were parallel with skin) per mm of hair stubble length.

SKIN INJURY FROM SHAVING

FIGURE 2

DISCUSSION

Porcine skin has many similarities to human skin.[2] The hair of the swine is sparse, much like that of the human's; however, it is longer and coarser, and unless it is removed by some method, the skin is not satisfactory as a bioassay substrate for thermal injury evaluation.

There are many advantages to simply clipping the pig prior to using the skin for the bioassay of thermal injury. The method is fast and requires minimal training to attain excellent proficiency. Several people can work simultaneously and large areas are quickly prepared; thus, anesthesia time

is short. It is the least irritating of any of the methods evaluated. The skin remains dry and the animal may be used immediately for the bioassay, facilitating preparation of the animal for the study and eliminating additional anesthetics.

The main disadvantage of the clipping technic is the remaining hair stubble. This stubble shades the skin from radiant and convective heat. Conflagration of the stubble adds another variable in the bioassay of thermal injury to the skin (albeit, human hair does the same for human skin). If, in addition, a fabric is to be tested between the fire source and the porcine skin,[13] the stubble acts as a scaffold and elevates the fabric away from the skin, providing an insulating air gap which Stoll has shown to be an important factor in flame retardant fabric testing.[14]

Shaving eliminated the problem of hair stubble but this method had some important disadvantages. The skill needed to wet shave the animal required considerably more training and even then gross trauma to the skin often occurred. Even a skillful razor preparation causes microscopic injuries.[1] Body folds, axillae, pubic, perineal, and scrotal regions make this method even more difficult.[3,5,7,8] The time involved in shaving was considerable. Safety razors decreased the skill needed and prevented some of the trauma, but this procedure was even more time consuming and utilized many razor blades at an additional cost. It was impractical, if not impossible. The wet skin surface after this procedure prevented immediate utilization as a bioassay substrate. Mechanical means of drying the skin shortened this time; however, additional anesthesia time or reanesthetization of the animal was necessary prior to its use as a bioassay substrate. In addition, the amount of epidermis removed during skillful shaving was difficult to determine and provided another variable. Finnerty has shown that blades remove an average of 4 to 15 times as many cells as electric shavers.[15] We did not evaluate the use of electric razors. Wound infections are reportedly higher in shaving preparations,[1] which could change the evaluation of the thermal injury in long range studies.

Depilation removed the hair stubble in a very satisfactory manner. The problems of traumatic injury to the skin were significantly less than with shaving. This contrast has been demonstrated in humans.[1,3] The depilatory agent did not have untoward effects on the areas of porcine skin tested as has been reported for other animals and in other anatomical locations.[3,6,7] The training required to prepare the surface for test in no way approximated the highly adept skill needed for shaving. The agent has been applied around

lacerations or over inflamed sites such as abscesses or areas of cellulitis with no deleterious effects.[3]

The agent worked much better when most of the hair was clipped away (per manufacturer's recommendation); however, this added additional time to the depilatory procedure which was already the most lengthy of the three methods evaluated. The procedure requires gentle scrapping to remove the agent, which, if one is not careful, can produce irritation not unlike that of shaving. Water is necessary to remove the remaining agent, thus adding the problems of drying the skin. Using the agent over large areas and in large numbers of experimental animals becomes quite expensive.

All factors must be weighed in establishing a protocol for thermal injury studies (Table 1) using porcine skin as the bioassay substrate. Increased manpower, monetary appropriations, or time for completion of the project may negate many of the disadvantages. Hair stubble, if uniform, may give just as reliable results as no stubble for most studies on thermal injury, but eliminating this variable would seem appropriate. Ideally, depilation followed by a short time interval to determine skin reactions and allow adequate drying of the skin (to eliminate variations in thermal transfer due to vaporation) would offer the best overall technical preparation (hair removal) of porcine skin for a bioassay substrate for thermal injury studies.

CONCLUSION

Three standard methods of hair removal were evaluated on porcine skin in preparation for its use as a bioassay substrate for thermal injury.

Clipping was fast, required the least manpower and training, and was the least irritating to the skin of all the methods. Animals could be used immediately as bioassay substrates for thermal injury studies. The resultant hair stubble may cause variations in thermal damage by shading and/or conflagration and by supporting an insulating air gap beneath fabric samples.

Shaving eliminated the problem of hair stubble but required extensive manpower and skill. It invariably traumatized the skin and required additional technics for drying the skin prior to use as a bioassay substrate for thermal injury.

Depilatory cream was superior to shaving or clipping in depilation of

test sites and resulted in test areas free of hair, stubble, cellular debris, and dermal excoriation. When used with clipping (as recommended) it required the greatest expenditure of manpower. Also, there was considerable monetary expenditure for the depilatory agent.

Depilation offered the best overall technical preparation of porcine skin for a bioassay substrate for thermal injury studies.

METHOD	FACTORS EVALUATED								
	Hair Stubble	Skin Trauma	Skill Required	Use In Difficult Areas	Time Required	Manpower	Preparation to Utilization Time	Type Preparation	Cost
Clipping	Present	Absent	Very Little	Fair	Very Little	Least	Least	Dry	Least
Shaving	Absent Initially	Always Present	Must be Highly Adept	Poor	Considerable	Consid-erable	Time Required	Wet	Moderate
Depilation	Absent Initially	Usually Absent	Some Required	Good	Extensive	Most	Time Required	Wet	Most

TABLE 1. Summary of Important Considerations for Each Method of Hair Removal Evaluated

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