

A Model for the Study of Skin Microcirculation

ELIZABETH A. SORRENTINO • HARVEY N. MAYROVITZ

Assessment and preservation of the integrity of the skin is a basic nursing function. Yet, little if any research has been directed towards expanding nursing knowledge in this area. The flow of blood through the skin is presumed to be an indicator of the general health and developmental state of patients (Heuther & Jacobs, 1986). Nursing observations such as pallor, blotching, cyanosis, or dryness of the skin are manifestations of some fascinating and interesting microvascular, physiologic phenomena. These can be studied, quantified, and characterized. Nurses can develop the necessary research skills to investigate microcirculation in a laboratory setting. This discussion is focused on the use of an *in vivo* animal model to study skin microcirculatory phenomena and proposed possible applications for nursing research.

A New Nursing Inquiry: The process of local homeostasis depends on the specific properties of the microvasculature (Wiedeman, Tuma, & Mayrovitz, 1981). It is at the microcirculatory level that nutritive exchange occurs. Tissue viability and function are dependent on microcirculatory hemodynamics which include the pressure and flow within the microvessels. Nursing clinical observations are indirect manifestations of these hemodynamics. Many nursing interventions are directed towards the maintenance of skin integrity; such as, turning every two hours to prevent pressure sores, light massage, or application of compresses. Nursing assessment of the skin reflects indirect changes

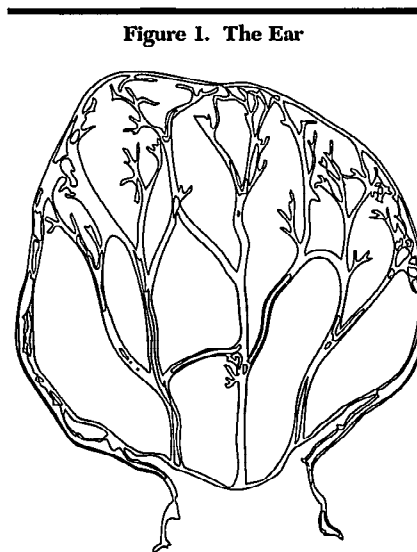


Figure 1. The Ear

NOTE: The three main arterioles enter at the base of the ear. Three venules (not shown) run alongside the arterioles. Occasional secondary branches communicate with the main vessels.

attributable to multisystem disease. Blood flow through the skin is likely to be affected by acute or chronic alterations in circulatory or neurological functions, nutritional states, and the aging process. The complex microcirculatory characteristics in each organ system affect the outcomes of many therapeutic interventions. Nurses have long considered the relationship of these factors. Patients at risk for skin breakdown are identified and appropriate intervention and teaching plans designed to maintain skin integrity. The bases for our knowledge regarding skin care can be enhanced with microcirculatory research.

The study of skin microcirculation allows the examination of the dynamics of blood flow under physiological and pathological conditions so that the efficacy of nursing interventions can be evaluated.

The macro-level assessment of the skin has been helpful in making judgments about underlying circulatory status. However, refinement of many nursing interventions can be significantly aided by initial microcirculatory studies using a reproducible, noninvasive animal model.

Homozygous Hairless Mouse Ear Model: The use of an animal ear model was first described by North and Sanders (1958). The homozygous, hairless mouse ear model has been considered superior and used by many investigators (Barker, Hammerson, Bondar, et al., 1989; Eriksson, Boykin, & Pittman, 1980; Boykin, Eriksson, & Pittman, 1980). The adult homozygous hairless mouse (Charles River Laboratories), 12 to 16 weeks old, weighs approximately 35–40 gm. The ears measure approximately 18 to 20 mm from the base to the tip and is 300 μ m thick. The surface area of each ear is about 6% of the animal's total body weight. The ear consists of two skin layers made up of sparse, striated muscle cells; connective tissue separates this from a thin layer of cartilage. The outer skin of the ear is pink and the vascular network is prominently displayed as illustrated in Figure 1.

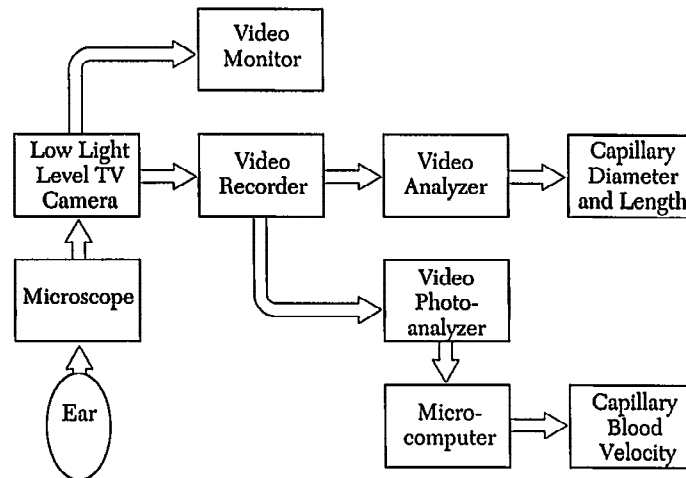
Typically, three arterioles enter and exit at the base of the ear. Secondary branches running alongside

the main vessels have been observed in several animals (Mayrovitz, Moore, & Sorrentino, 1990). These, in turn, branch to the precapillary arterioles, capillary loops, and postcapillary venules. The capillaries frequently bifurcate to circumscribe the hair follicles. Occasional intermittent capillary flow and flow reversals are also observable. As in the skin of human digits, the ear contains many arteriovenous anastomoses with a diameter of 10 to 12 μm (Eriksson, Boykin, & Pittman, 1980).

The preparation of the animal for observation is not complicated and requires no surgery. Nembutal (6.0 mg/100 g.bwt) is given intraperitoneally with a maintenance dose given every two hours. With the animal under full effects of the anaesthesia, its ear is positioned on a slide mount. One ear can be used for treatment and the other used as control. Observations may be conducted while the animal is housed in a Plexiglas observation chamber (Boykin, Eriksson, & Pittman, 1980). From our experience, this limits access to the experimental site. We have found that the use of a regular slide with a standard microcoverglass over the ear provides more than adequate observation area. Further, this minimizes time involved in positioning the animal and the ear. When doing comparative studies, it is important to measure and/or control the ear temperature. The examination under a trinocular microscope is done with a video camera mounted on top for recording data. A block diagram in Figure 2 shows the system. This allows the experiment to progress smoothly with data analysis completed at a later time.

We used the homozygous, hairless mouse ear as a model to quantitatively characterize the effects of ischemia on the microvasculature (Sorrentino & Mayrovitz, 1990). The uniqueness of this model lies in being able to document all phenomena such as blood flow velocity, flow time, vessel diameters, and capillary topography via video camera before, during, and after ischemia. In addition, it allows follow-up. There is tremendous value in making actual observations during the experimental treatment. In this case, ligation of supplying arteries to induce zero flow to defined capillaries, is verifiable and documented. Where most experimental models require extensive surgical preparation, this method is simple and inexpensive. The mouse is also fully recoverable for chronic studies (Barker et al., 1989; Mayrovitz, Moore, & Sorrentino, 1990).

Figure 2. Data Acquisition and Analysis System



Results from animal experiments may be extrapolated to humans with caution. The examination of the wound healing process using the homozygous, hairless mouse model is one example of how laboratory studies can be used to examine efficacy of nursing treatments. The positive or negative outcomes of treatments can be documented and quantified. Nursing treatments may include the type of dressing used, the exposure to light, the use of warm compresses or emollients. Answering research questions in this regard may enlighten us in identifying appropriate nursing policies, procedures, and standards of care.

Model Use in Nursing Research:

Many nursing concepts or abstractions such as pallor, blanching, cyanosis, granulation, or mottling are manifestations of certain disease states. For example, in burn injury, we observe variations in the affected tissue. We observe differences in granulation and color of tissue. In pressure ulcers and following reconstructive vascular surgery, ischemia of skeletal muscle and skin is a common clinical problem (Sack, Hammerson, & Messmer, 1987). Nursing treatments have been directed at prevention of further tissue damage, as well as facilitating the healing process. The examination of microcirculatory changes associated with injury and healing in the skin can be studied using the homozygous hairless mouse ear model to provide a better understanding of why healing occurs under certain conditions and not in others. One factor is the supply of blood to an injured area. This has been identified as a crucial factor for tissue regeneration in the wound (Baker & Nastuk, 1986). The normal and delayed healing process of skin wounds

may be examined. The parameters in an experimentally induced injury on the ear can be compared to control values on the opposite ear as control. Repeated vital microscopic observations of the healing process can allow follow-up that enhances understanding of how pathophysiology affects the microcirculatory level and how specific nursing interventions affect healing. For example, we can study the effects of occlusive wound dressings (Darr, Lalagos, & Upman, 1989) and compare this to a moist environment for wound healing (Alvarez, Rozint, & Wize-man, 1989). Nurses can examine factors in impaired wound healing (Stotts, 1986), in particular, open surgical wounds (Stotts, 1990) and exuding pressure sores (Motta, 1989). Although these studies did not utilize the hairless mouse ear model, the phenomena under examination can, indeed, be done using the animal model described herein.

In diabetes, the skin circulation is altered to the extent that poor skin turgor, dryness, and lesion formation occur. Even the process of wound healing may be affected and thus, is an area for investigation (Bondar, Barker, Galla, Uhl, & Messmer, 1988). Diabetes can be induced using this animal model. Again, manifestations of blood flow in the setting of diabetes can be observed and quantified and the effect of interventions such as emollients, compresses, or pharmaceuticals assessed.

The study of skin microcirculation using the ear of the homozygous hairless mouse allows us to explore research questions in microcirculation which ordinarily may not be answered using human subjects. It enables control over many confounding variables

and can allow extrapolation to human microcirculation, an open area for nursing research. **NR**

Accepted for publication May 1, 1990.

This study was supported in part by grants from the American Heart Association Florida Affiliate (G-18) and the Juvenile Diabetes Foundation International (1891090).

ELIZABETH SORRENTINO, PHD, RN, is associate professor at the School of Nursing, University of Miami, Miami, FL.

HARVEY N. MAYROVITZ, PHD, is Chief, Microvascular Studies Unit, Miami Heart Institute, Miami Beach, FL.

References

ALVAREZ, O., ROZINT, J., & WIZEMAN, D. (1989). Moist environment for wound healing: Matching the dressing to the wound. *Wounds*, 1.

BAKER, C. H., NASTUK, W. L. (1986). *Microcirculatory technology*. Florida: Academic Press.

BARKER, J. H., HAMMERSON, F., BONDAR, I., UHL, E., GALLA, T., MENDER, M., & MESSMER, K. (1989). The hairless mouse ear for in vivo studies of skin microcirculation. *Plastic*

and *Reconstructive Surgery*, 83, 948-959.

BONDAR, T., BARKER, J. H., GALLA, T. H., UHL, E., & MESSMER, K. (1988). A new model to study microcirculatory changes during wound healing in the skin. *International Journal of Microcirculation*, 7.

BOYKIN, J. V., ERIKSSON, E., & PITTMANN, R. N. (1980). In vivo microcirculation of a scald burn and the progression of postburn dermal ischemia. *Plastic and Reconstructive Surgery*, 66, 191-198.

DARR, R., LALAGOS, D. E., & UPMAN, P. J. (1989). Comparative study of occlusive wound dressings on full thickness wounds in domestic pigs. *Wounds* 1.

CUNNINGHAM, S. G. & MITCHELL, P. H. (1982). The use of animals in nursing research. *Advances in Nursing Science*, 4(4), 72-84.

ERIKSSON, E., BOYKIN, J., & PITTMANN, R. (1980). Method for in vivo microscopy of the cutaneous microcirculation of the hairless mouse ear. *Microvascular Research*, 19, 374-379.

HEUTHER, S. E., JACOBS, M. K. (1986). Determination of normal variation in skin blood flow velocity in healthy adults. *Nursing Research*, 35, 162-165.

MAYROVITZ, H. N., MOORE, J., & SORRENTINO, E. A. (1990). A method for producing regional microvascular ischemia. *Microvascular Research*, 39(3), 390-394.

MOTTA, G. J. (1989). Calcium alginate topical wound dressings: A new dimension in the cost-effective treatment for exuding dermal wounds and pressure sores. *Ostomy/Wound Management*, 25.

NORTH, K. A. K., & SANDERS, A. G. (1958). The development of collateral circulation in the mouse ear. *Circulation Research*, 6, 721-727.

SACK, F. U., HAMMERSON, F., & MESSMER, K. (1987). Microvascular injury of skeletal muscle and skin after different periods of pressure-induced ischemia. *Progress in Applied Microcirculation*, 12, 282-288.

SORRENTINO, E. A., MAYROVITZ, H. N. (in press). Skin capillary reperfusion after regional ischemia. *International Journal of Microcirculation: Clinical and Experimental*.

STOTTS, N. (1986). Impaired wound healing in pathophysiological phenomena. In V. Carrieri, A. Lindsay, and C. West. (Eds.), *Nursing: Human response to illness*. Philadelphia: W. B. Saunders.

STOTTS, N. (1990, February). Seeing red and yellow and black: The three-color concept of wound care. *Nursing* 90, 59-61.

WIEDEMAN, M., TUMA, R. F., & MAYROVITZ, H. N. (1981). *An Introduction to Microcirculation*. New York: Academic Press.

CALL FOR PAPERS

Fourth National Conference
on Research for Clinical Practice

Key Aspects of Caring for the Chronically Ill: Hospital and Home

Nurses in hospitals, long-term care, community settings, and home health play key roles in caring for the chronically ill—from neonates to the elderly—and in helping these patients and their families maintain quality of life. Nurses deal with acute episodes, ease transitions between hospital and community, and promote functional independence. They assist families and patients to deal with high-tech home care, manage complex regimens and live with persistent problems. **Summaries of research on these key aspects of continuing care for the chronically ill are solicited for a national conference and volume of research and discussion.** The conference, to be held in Chapel Hill, NC, April 23-25, 1992, will bring together researchers, clinicians, and administrators to examine current research and practice in caring for the chronically ill and to explore strategies for moving the new knowledge into practice. Presenters will be provided a small honorarium. The conference is sponsored by the University of North Carolina at Chapel Hill School of Nursing, Alpha Alpha Chapter of Sigma Theta Tau, and the Southern Nursing Research Society. Five-page summary submission deadline is **October 15, 1991**. Contact Ruth Wiese, School of Nursing, CB# 7460 Carrington Hall, University of North Carolina, Chapel Hill, NC 27599-7460, 919-966-2263.

MOVING?

GIVE US
YOUR NEW ADDRESS
SIX WEEKS AHEAD

To ensure proper service when you change your address or whenever you write to us about your NURSING RESEARCH subscription, please include your address label from a recent issue of NURSING RESEARCH. Address your correspondence to NURSING RESEARCH Subscription Change of Address Dept., P.O. Box 1728, Riverton, NJ 08077-7328.

Affix address label here when sending address change. Clearly print NEW address. The expiration date of your subscription is toward the right end of the upper portion of the label.

Name _____

Address _____

City _____

State _____ Zip _____