Panel Summary

Geriatric anaesthesia

Participants
Douglas B. Craig MD FRCPC (Chairman)
Department of Anesthesia, University of Manitoba, Winnipeg, Manitoba
Charles H. McLeskey MD
Department of Anesthesiology, University of Texas Medical Branch, Galveston, Texas
(Anatomical and physiological changes of aging)
Paul A. Mitenko MD FRCPC
Department of Internal Medicine, University of Manitoba, Winnipeg, Manitoba
(Changes in drug disposition)
Ian R. Thomson MD FRCPC
Department of Anesthesia, University of Manitoba, Winnipeg, Manitoba
(Cardiac risk assessment and reduction in the elderly)
Kenneth M. Janis MD
Departments of Anesthesiology, University of California, Irvine and San Diego, California
(Anaesthetic management of the geriatric patient)

Introduction

Increasing numbers of elderly patients are presenting for surgery, much of it major, requiring lengthy and complicated operative and postoperative courses. Advances in both surgery and anaesthesia are likely the primary basis for these increasing numbers, as opposed to the well-publicized "greying" of the North American population. Whatever the basis for the changes, anaesthetists are now being presented with increasing challenges in the anaesthetic management of geriatric patients. This panel reviewed the information base for a developing new subspecialty – geriatric anaesthesia.

Dr. McLeskey began with a review of the anatomical and physiological changes of aging, with a special emphasis on anaesthetic implications. He noted that an understanding of the anaesthetic implications of the physiologic changes of aging is essential as the basis for appropriate decisions concerning anaesthetic management of geriatric patients.

Dr. Mitenko reviewed the effects of aging on drug absorption, distribution, metabolism and excretion. He noted that while characteristic age-related patterns of change have been described, because chronologic age is a notoriously poor indicator of biologic age, and since drug response is the end result of a series of many interrelated steps, individualization of therapy is the key requirement.

Dr. Thomson reviewed a number of approaches to cardiac risk assessment, ranging from the medical history to invasive procedures. The as yet incomplete and inconclusive literature on risk reduction was examined.

Dr. Janis used the experience of a large geriatric centre in southern California to discuss the anaesthetic management of the geriatric patient. Proper patient selection and preparation, along with a high incidence of local or regional anaesthesia, and an emphasis on outpatient procedures, has been associated with a high degree of success.

Based on presentations given at the Annual Meeting of the Canadian Anaesthetists' Society in Montreal, Quebec, June 25, 1986.

Anatomical and physiological changes of aging

In 1980, 23,000,000 Americans were 60 years of age or older and it is predicted that this age group will expand by the year 2050 to include 55,000,000 Americans. For the purpose of this discussion, we will arbitrarily consider individuals 65 years of age or older to be in the geriatric group. An understanding of the anaesthetic implications of the physiologic changes of aging is essential as the basis for appropriate decisions concerning the choice of and methods for administering anaesthesia to geriatric patients.

Decreased basal metabolic rate

Basal metabolic rate declines approximately one per cent per year beyond age 30 (Figure). Therefore, anaesthetic

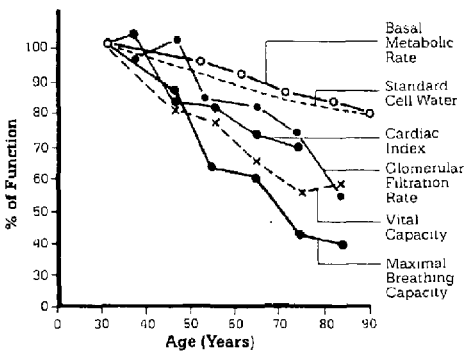

FIGURE The percentage of remaining function for a variety of physiologic functions affected by aging. In general there is a decrement in most physiologic parameters of approximately one per cent per year after age 30. (Reproduced with permission, *Evans TI*. Anaesth Intensive Care 1973; 1: 319–22.)

agents will be metabolized and excreted much more slowly in elderly patients compared to younger patients. In addition, since the metabolic rate is lower in elderly patients, the requirement for anaesthetic agents in this age group will likely be less.

Decreased central nervous system function

Like basal metabolic rate, the function of most organs, and most importantly, that of the central nervous system (CNS) declines during the aging process. Dementia which occurs with aging may be due to localized areas of microemboli or, more commonly, due to a gradual process of decreased cerebral blood flow and decreased CNS activity (Alzheimer's disease). This very gradual process may not be distinguishable in a given patient, but the likelihood is that geriatric patients in general will have reduced requirements for anaesthesia due to a gradual reduction in CNS activity. The minimum alveolar concentrations (MAC) for most inhalational agents gradually reduce with increasing age. This same principle is also seen with regional anaesthesia where smaller doses of local anaesthetics are required to produce the same level of epidural or spinal anaesthesia.

Decreased airway reflexes

During laryngoscopy of an elderly patient, it is not uncommon to find foreign material retained in the posterior pharynx. This finding would be very unusual in younger patients. Laryngeal, pharyngeal, and other airway reflexes are less effective in older individuals. Pontoppidan found that a much larger volume of inhaled ammonia vapour was required to produce breath holding (airway protection) in older patients compared to younger patients. The anaesthetist must be aware of the fact that elderly individuals are less able to prevent pulmonary aspiration of foreign material than are younger patients.

Decreased serum protein

Protein binding is a primary determinant of the effectiveness of intravenous anaesthetic agents and narcotics. Portions of administered drugs that are protein bound remain in plasma and are ineffective in producing an effect. The unbound portions can cross membranes to enter the CNS and produce an effect. As individuals age, the circulating level of serum protein, especially albumin, and the binding effectiveness of circulating protein are reduced. Thus, a greater percentage of drugs is present in the geriatric patient in an unbound or effective state, and as a result, a reduced dose of intravenous anaesthetic agents should be administered.

Increased percentage of body fat

At age 60, lean body mass (muscle) has been reduced approximately ten per cent from age 20 levels. During the same time period, there is also an approximate ten per cent increase in the percentage of body weight which is fat. Due to their high lipid solubility, anaesthetic agents will be stored in the adipose tissue. Since elderly individuals have a greater percentage of body fat compared to younger patients, for the same administered dose of an anaesthetic agent, a greater amount of drug will be sequestered. This has the effect of delayed emergence from anaesthesia since there is a protracted efflux of these agents from the lipid storage sites into the circulating blood.

Decreased salivation

Salivation decreases with aging, with the result that when laryngoscopy is done in an elderly patient, the mouth and tongue frequently appear very dry, despite adequate general hydration. The need for routine anticholinergic premedication, in the hopes of reducing salivation, is therefore reduced in the elderly patient.

Decreased cardiovascular reserve

The cardiovascular changes with aging are perhaps of more importance to the anaesthetist than any of the other age-related physiologic changes. Cardiac index has classically been described as falling approximately 1% per year after age 30 (Figure). If true, this would result in delayed induction with intravenous anaesthetic agents. For example, a test dose of thiopentone may not demonstrate any effect in an elderly patient during the time frame when one expects to see a slight decrease in blood pressure or an increase in sedation in a younger patient. If

adequate time is not allowed in the elderly to permit the delayed delivery of intravenous agents to target organs (brain, etc.), then one may inadvertently give a repeat dose which is too large, thinking that the initial dose had no effect. On the other hand, with slower circulation times we can expect a faster onset of inhalational anaesthesia. Since cardiac output is reduced, the uptake of inhalational anaesthetic agents from the lung will be reduced, allowing for a more rapid achievement of a high partial pressure in the alveoli which is reflected as a higher partial pressure in the blood and, in turn, in the brain, the factor responsible for anaesthetic effects.

More recently, the classic notion of a relatively constant gradual decline in cardiac output with aging has been challenged. Data from the Baltimore Longitudinal Study and others have shown that among individuals motivated enough to return to Baltimore for biannual physical fitness evaluations that cardiac output seems relatively well maintained and unchanged from approximately age 30 to age 60, at which point cardiac output may decline rather rapidly. One wonders if these individuals represent the average American citizen of today or rather a sub-set of the citizenry which if motivated enough to return for repeated testing may also be motivated enough to undertake a chronic physical fitness program at home. If so, it speaks well for the potential maintenance of our physical well being during the aging process if modest amounts of physical exercise are undertaken on a long-term basis. When combining the classic view of age-related changes in cardiac output with the newer information from the Baltimore Longitudinal Study, I conclude that it is very difficult to anticipate the reserve cardiac function in any given elderly patient who presents for surgery. It seems likely to me that if this individual has paid attention to physical fitness for much of his life, his cardiac status may very well be more similar to that of a much younger person than that of an elderly individual who has not paid the same attention to physical fitness. This reemphasizes the potential great physiological variability that may be seen in elderly individuals presenting for surgery.

Although resting stroke volume remains relatively unaffected by the aging process, the normal response to stress may be impaired. Healthy young individuals respond to stress, such as exercise, by increasing ejection fraction 10 to 25% compared to resting values. However, the elderly are unable to respond to stress by significantly increasing their left ventricular ejection fraction and, in fact, they may have a reduction in ejection fraction. Similarly, the maximum heart rate which may be generated by an elderly patient is considerably less than that of a younger patient.

During the aging process, elastic tissue in the pulmonary parenchyma, skin, and other organs is replaced by less resilient fibrous connective tissue. This process is of particular importance when it occurs in the aorta and other large vessels. Total peripheral resistance is increased as the rigidity of the vasculature increases and elasticity of the vasculature decreases, which explains in part the greater frequency of hypertension and hypertensive cardiovascular disease in geriatric patients.

Decreased pulmonary reserve

Pulmonary changes which occur during aging affect both the musculoskeletal supporting structure of the lung as well as the parenchyma of the lung itself. The chest becomes more kyphotic, with gradual compression of the intervertebral discs. Arthritic changes occur in the ribs and costochondral junctions which reduce total lung capacity. Muscle wasting reduces the effectiveness of the diaphragm and intercostal muscles. As a result, maximum breathing capacity, total lung capacity and vital capacity all decline with increasing age (Figure).

The age-induced parenchymal changes of the lung mimic those of emphysema. Gradually, alveolar septae are lost, with expansion of the alveolar spaces. In addition, since the alveolar septae have an effect of producing radial traction on the terminal bronchioles, a reduction in the quality of the alveolar septae makes the support framework for the terminal bronchioles less stable. These terminal bronchioles are therefore more likely to collapse and, as a result, the "closing volume" of the lung increases. Thus, greater portions of tidal ventilation occur at lung volumes below closing volume resulting in air trapping and V/Q mismatch which produce a gradual age-related decline in PaO_2.

Because pulmonary reserve is reduced in the elderly patient, postoperative mechanical ventilation is more likely to be required. These patients may be less able to cough and clear their secretions and may require additional pulmonary toilet postoperatively. Because of the gradual decline in resting arterial PO_2 and the increase in V/Q mismatch which occurs with aging, exaggerated by the supine position and by general anaesthesia, the anaesthetist may very wisely select an anaesthetic technique which includes at least 50 per cent oxygen. Higher inspired oxygen concentrations may be required if arterial PO_2 values are unacceptable even at this increased inspired oxygen concentration.

Decreased hepatic and renal function

Like most other body functions, hepatic and renal function are reduced about one per cent per year after age 30. Renal blood flow decreases about 1.5 per cent per year and is accompanied by a gradual loss of functioning glomeruli. The combination of these changes produces a

gradual decline in glomerular filtration rate (Figure). These renal changes result in a reduced ability of the elderly patient to excrete administered drugs and also to excrete normally metabolized waste body products. For example, creatinine, a normal metabolite of muscle creatinine has a reduced excretion rate in the elderly patient. However, despite a decline in glomerular filtration rate, healthy elderly patients have the same circulating level of serum creatinine as younger patients because they have less skeletal muscle and, therefore, less muscle metabolism and creatinine production. If serum creatinine levels are elevated in an elderly patient, this implies a severe decrement in renal function, greater than the expected age-related decline.

Most administered anaesthetic agents are highly lipid soluble. Lipid soluble drugs filtered by the glomeruli are readily reabsorbed by renal tubules and therefore are not excreted. The liver converts lipid soluble drugs by glucuronidation or other metabolic processes into water soluble metabolites which, after filtration by the glomeruli, are reabsorbed less readily by the renal tubules and excreted. As a result of the aging process, the ability to both metabolize and excrete anaesthetic drugs is impaired. For example, the elimination half life ($t_{\frac{1}{2}}\beta$) of fentanyl is 265 minutes in young patients compared to 945 minutes in elderly patients. The reduced clearance of drugs in the elderly patient also affects muscle relaxants, which suggests muscle relaxants should be administered at less frequent intervals than in younger patients.

Anaesthetic implications

The effect of anaesthetic drugs in elderly patients is usually exaggerated due to a reduced volume of distribution and reduced protein binding. The reduced CNS function in elderly patients may also contribute to their greater sensitivity to intravenous and inhalational anaesthetic agents. As a result, the anaesthetic must, in general, reduce the dose of administered intravenous agents in the elderly patient. Since accumulation of fat-soluble drugs is enhanced due to a higher percentage of body fat, lipid soluble drugs may be expected to have a longer duration of action in these patients. Because the basal metabolic rate and hepatic and renal functions are reduced, metabolism and elimination of anaesthetic drugs will be impaired and again a longer duration of action may be expected.

Cardiac output is reduced. We should therefore expect a delayed onset of action following administration of intravenous agents and a more rapid onset of action with inhalational anaesthetics. Intravenous drugs must be administered not only in reduced dosages but, because of reduced clearance should also be reinjected less frequently. Finally, because of lower resting arterial PO_2 values and higher closing volumes, attention to pulmonary toilet and ventilatory assistance postoperatively is crucial in geriatric patients. Similarly, they may require a higher FiO_2 when undergoing operative procedures than do younger patients undergoing similar procedures.

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Changes in drug disposition

It is of interest that the chapter on alterations in drug disposition in a recently published textbook on geriatric anaesthesia deals almost exclusively with systemically administered drugs, and not much with inhalational agents.[1] The whole problem of changes in disposition of inhalational agents is an intriguing one, and the demonstration that minimum alveolar concentrations (MAC) of isoflurane and halothane decrease with age highlights the difficulty of differentiating pharmacokinetic differences from pharmacodynamic differences.[2,3] If an age-related difference in drug response is shown to exist, it must be demonstrated that changes in drug disposition are not important before changes in drug effect can be inferred.