to a circle filter ranged from 0.45 to 0.90 per cent. The amount varied depending upon the size of the mask. Converting the inhaler to a semiclosed system and flowing 1 to 15 liters per minute into the system caused no remarkable reduction in the amount of CO_2 rebreathed. Mounting the exhalation valve at the mask instead of at the canister did not reduce the degree of rebreathing at demand or higher flow rates. No difference was noted in the amount of CO_2 rebreathed when the circle filter was arranged so that the respiratory valves were placed at the mask and in the conventional manner on the canister with total rebreathing or with semiclosed arrangements at demand or higher flow rates. By substituting an endotracheal connector for the mask, the volumes rebreathed were decreased from 100 cc. to 15 cc. The percentage of CO_2 decreased from 0.45 to 0.1 per cent. These studies were performed using tidal volumes of 500 cc. at a respiratory rate of 20 per minute and a CO_2 input of 200 cc. per minute diluted to 2 per cent with oxygen. Tidal volumes ranging from 10 to 50 cc. and respiratory rates ranging from 20 to 60 per minute, as might be encountered in infants and children, were used to study apparatus ordinarily used for pediatric anesthesia. The exhaled CO_2 concentration was maintained at 2 per cent as in the adult studies. The percentage carbon dioxide rebreathed averaged from 0.2–0.45 per cent using a Yankauer mask of pediatric size without gauze. With five layers of gauge it was 1.15 per cent; ten layers to 1.50 per cent and fifteen layers to 2.0 per cent. Apparently the turbulence and diffusion created by the small tidal exchange is inadequate to force the gas beyond the confines of the wire screen. Again, flowing gas beneath the mask was of no benefit. The Ayres tube, 1 cm. in diameter, 4 cm. long with a 2 cm. side arm, was studied. Without any gas flowing into the tube and a tidal volume of 10 cc., 1.6 per cent carbon dioxide was rebreathed. With a 50 cc. tidal volume and a rate of 40, it was 0.7 per cent. The figures at respiratory rate 20, 30 and 60 differed little from those at 40. The amount of carbon dioxide rebreathed gradually decreased as the flow of gas was increased, until at a flow of 10 liters, the amount rebreathed reached a stable point averaging 0.3 per cent. When the tidal exchange was decreased to 10 cc. and the respiratory rate was maintained at 40 per minute, complete rebreathing of carbon dioxide occurred at zero flow rate. As the side arm was lengthened to 3½ cm., the CO_2 rebreathed decreased gradually to 0.95 per cent as the flow rate was increased to 15 liters. Obviously considerably more rebreathing occurs at the smaller tidal volumes. The Stephen-Slater "nonrebreathing valve" connected to the ventilating machine, with an endotracheal connector in the manner that it is connected to a patient, showed an average of 0.95 per cent CO_2 rebreathed at 10 cc. tidal volume and respiratory rates from 20 to 60 per minute. With tidal volumes averaging 50 cc., the amount rebreathed decreased to 0.7 per cent. The smallness of the dead space between the connector and the inspiratory valve is deceptive. The results using the closed system with face pieces of pediatric sizes, were similar to those of adults. Using the Ohio Chemical Co. pediatric circle filter and a small mask of 15 cc. volume at 10 cc. tidal volume, an average of 1.1 per cent returned in the inspired gases. At a 50 cc. tidal volume the amount returned averaged 0.9 per cent. As the size of the mask was increased, this figure increased in proportion from 1.5 per cent average to 1.9 per cent at the 10 cc. tidal volume. The Bloomquist and modified Foregger pediatric (Adriani) equipment gave similar results. With to-and-fro apparatus and a 50 cc. canister, complete rebreathing (2 per cent CO_2) occurred using tidal volumes of 10 cc. When the tidal volumes were increased to 50 cc., the rebreathed concentrations decreased to 1.1 per cent. This follows the same general pattern as observed using the adult to-and-fro at adult tidal volumes. In the case of pediatric equipment, the least rebreathing occurred with the Ayres tube.

Anesthesia in the Asthmatic Patient. MARTIN I. GOLD, M.D., AND MARTIN HELRICH, M.D., *Department of Anesthesiology, University of Maryland, School of Medicine, and University Hospital, Baltimore, Maryland.* During a 36 month period at the university hospital, 220 anesthetics were administered to 196 patients with bronchial asthma and/or chronic obstructive airway disease. Fifty-three asth-

matics (24 per cent) encountered 67 complications during and after the surgical-anesthesia event. Fifty complications were respiratory; this did not include 9 postoperative fatalities, of which 8 occurred more than 3 days after anesthesia. Serious airway obstruction manifested itself during the course of 21 anesthetics including 14 asthmatic attacks (bronchospasm). All complications were studied to uncover significant trends relating several variables with complications. *Method and Results:* The anesthetic agents were arbitrarily divided into 3 general types: (1) Conduction anesthesia: of 47 such procedures, 6 instances of intraperitoneal surgery during high spinal anesthesia resulted in 5 patients developing 9 respiratory complications (operative and postoperative). (2) General anesthesia, other than halothane: 91 asthmatics were given 8 combinations of various agents including cyclopropane. Seventeen patients (61 per cent) developed 23 complications including 9 instances of bronchospasm, 4 cases of airway obstruction and 10 postoperative sequelae. (3) Halothane anesthesia: Of 82 such anesthetics 21 patients had additional agents. This miscellaneous subgroup included 8 patients with 9 complications (2 bronchospasm). The remaining 61 asthmatics were given halothane-nitrous oxide. Six patients (10 per cent) had 6 complications, only 1 occurring during anesthesia. Two complications were respiratory and no bronchospasm was encountered. Seriousness of asthma was the second variable studied. With the use of history, physical examination and occasionally pulmonary function tests, all asthmatics were arbitrarily placed in either grade I (mild, 95 patients), grade II (moderately severe, 72 patients) or grade III (very severe, 53 patients). While grade III asthmatics encountered most complications, no significant correlation resulted between seriousness of asthma and morbidity and mortality. Thoracic, upper and lower abdominal operations were associated with far more complications (approaching 50 per cent) than surgery of the perineum, extremities, head or neck (about 12 per cent of complications). Study of duration of surgery revealed a logarithmic rather than linear relationship between increasing duration and morbidity. Surgery in the asthmatic of longer than 2 hours was associated with a 29 per cent or higher complication rate. It is probable that duration is related to site of surgery. Sex, the fifth variable studied, revealed that the male asthmatic had significantly more complicaitons (30 per cent) than females (18 per cent), including twice the incidence of postoperative death and two-and-a-half times the incidence of bronchospasm. Other variables were studied including the influence of age, physical status, smoking, preoperative medication, muscle relaxants and endotracheal intubation. Under the conditions of this study we were unable to establish any relationship between these variables and complications.

Protection by Digitalization Against the Negative Inotropic Effect of Halothane in Dogs. ALAN H. GOLDBERG, M.D., HARRIET M. MALING, PH.D., and THOMAS E. GAFFNEY, M.D., *National Institutes of Health, Bethesda, Maryland.* In 9 open chest dogs (9–15 kg.), comparisons were made of the depressant effects of halothane on heart contractile force (strain gauge arch) and mean arterial pressure before and after digitalization. *Method:* Following tracheal intubation facilitated by intravenous succinylcholine (5 or 10 mg.), anesthesia was produced by halothane (0.3 to 1 per cent) and oxygen under intermittent positive pressure respiration. A strain gauge arch was then sutured to the right ventricle and a catheter was inserted into a femoral artery. Halothane was administered in the following sequence: 0.2, 1, 0.2 and 2 per cent, both before and one hour after the intravenous injection of digoxin (0.1 mg./kg.) to 6 of 9 dogs. During the hour interval between the digoxin injection and the second sequence of halothane inhalation, the succinylcholine injection, used initially for tracheal intubation, and the same concentrations of halothane which had been used for the application of the strain gauge arch and the insertion of the arterial catheter, were repeated. It was then possible to consider each dog as its own control. Each halothane concentration was given for 15 minutes. With 3 dogs, the above protocol was followed exactly with the exception of the digoxin administration in order to study the inotropic and pressor effects of repeated administrations of halothane alone. *Results:* The average decreases in heart contractile force produced by 0.2, 1 and 2 per cent halothane