Fig. 1. $P_{A02}$ calculated for different ambient pressures and $P_{AC02}$ levels. Upper line: $P_{102}$ at different levels of ambient pressure. Three lower lines: $P_{A02}$ at different levels of ambient pressure, for $P_{AC02}$ of 30, 40 and 50 mm Hg.

Fig. 2. $P_{a02}$ and $P_{v02}$ as related to ambient pressure, $P_{sc02}$ and degree of venous-arterial (right-to-left) shunting – (I) $P_{sc02} = 40$ mm Hg, $R-L$ shunt = 0%; (II) $P_{sc02} = 50$ mm Hg, $R-L$ shunt = 0%; (III) $P_{sc02} = 50$ mm Hg, $R-L$ shunt = 10%.

these deviations on the $P_{a02}$. Such a person is likely to have few subjective symptoms and lead a normal life. It can be seen in Figure 2 that ambient pressures, which are considered to be normal for pressure cabins, now result in $P_{a02}$-levels which are in the steep part of the oxyhemoglobin dissociation curve. Of more interest than the $P_{a02}$
is the mixed venous oxygen partial pressure \( (P_{\text{Vo}_2}) \), which is indicative of the lowest tension at which oxygen is offered to the cell. If a normal arteriovenous oxygen difference of 6 vol % is assumed, the result can be calculated. The values are given in the three lower curves of Figure 2. Here also it can be seen that people with mild respiratory disease have a very narrow safety margin of oxygenation when travelling in an airplane. Indeed, it can be expected that a number of passengers have to compensate slightly for a level of oxygenation which is not quite sufficient. This compensation takes place in the form of an increase in cardiac output, resulting in a decrease of the arteriovenous \( O_2 \) difference.

A second factor which should be taken into account, is smoking. Smoking produces carbon monoxide (CO), and carbon monoxide is known to be a highly potent toxic agent when the \( P_{\text{Io}_2} \) is below normal. In heavy smokers, it can be found that up to 15% of the total amount of hemoglobin is bound to CO. This value corresponds with a \( P_{\text{aco}} \) in the blood of 0.08 mm Hg. If we now take this heavy smoker to an ambient pressure of 600 mm Hg, his \( P_{\text{Ao}_2} \) will decrease to about 65 mm Hg. If he continues smoking, and so maintains a high level of \( P_{\text{Ico}} \), the \( P_{\text{aco}} \) will now be sufficient to bind 20% of the available hemoglobin instead of 15%. In itself this would be of little consequence, but apart from combining with hemoglobin CO shifts the oxyhemoglobin dissociation curve to the left. Oxygen is therefore delivered to the cell at a tension which is 6 to 9 mm Hg lower than without the presence of CO in the example just given. To compensate for this low \( P_{\text{Vo}_2} \), the cardiac output would have to increase with a factor of the order of magnitude of 1.5 to 2. It is unlikely that this will take place, so that the tissues will remain slightly but definitely lacking \( O_2 \). This is because cardiac compensation is known to be poor during CO-poisoning, due to the fact that the \( P_{\text{ao}_2} \) is not affected.

From what has been said above, it becomes clear that when air is breathed the lower limit of safety has been reached at 575 mm Hg ambient pressure. Below this limit we enter into a level in which compensated hypoxia exists, which may be symptomless and hard to define with objective signs, but which is nevertheless a reality.

At lower ambient pressures, \( O_2 \)-breathing is generally resorted to. This first involves the process of denitrogenation. The nitrogen (\( N_2 \)), which is in solution in the tissues, is transported to the lungs and excreted. Theoretically, this might give rise to diffusion hypoxia, the \( N_2 \) displacing the \( O_2 \) molecules from the alveoli. This process is well known to anesthesiologists, since it is an important cause of hypoxia during the first 5 to 10 min following nitrous oxide anaesthesia. Since the solubility coefficient of \( N_2 \) is low, this will hardly play a role during increasing altitude, provided that \( O_2 \)-breathing is commenced in good time and the decrease in the ambient pressure is not too fast.

Once denitrogenation has taken place, very low ambient pressures can be tolerated without the danger of hypoxia. Safety will now largely depend upon the fit of the face mask. A conventional mask may easily leak as much as 40%. This would still be quite satisfactory to use as an emergency mask in airplanes which fly at an altitude of about 8000 m. Even with a maximal leak it would then still provide for a \( P_{\text{Ao}_2} \) of about