Considerations for the Ambulatory Cardiopulmonary Patient as Concerned with Commercial Supersonic Transportation*

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From July, 1964 to July, 1965 over 84.5 million passengers were carried by scheduled airlines in the United States. Armstrong estimated that 3 per cent of airline passengers are ambulant patients. This could mean that over 2.5 million ambulatory patients were flying during that time. Physicians are being asked by their patients in ever-increasing numbers whether they can travel safely by air. A method of evaluating such requests for subsonic air travel has been reported previously. With the advent of commercial supersonic air transport (SST), physicians must be prepared to evaluate a patient's ability to use this attractive means of transportation.

Although the supersonic transport (SST) is still on the drawing board, certain physiologic criteria are abundantly apparent which lend themselves to consideration with respect to ambulatory cardiopulmonary patients (Table 1). The speed of sound varies with the altitude and other factors, but is approximately 600 to 700 miles per hour. In engineering terminology, this is designated mach 1. Aircraft traveling at twice or three times the speed of sound will be designated as mach 2 and mach 3 type airplanes, respectively. Currently, both of these types of aircraft are being considered for production.

Acceleration is a change in speed such as occurs during take-offs and landings. The accelerative forces for the Concord aircraft (mach 2) are expected to resemble those of the current subsonic jets now in civilian service. However, because of the flight pattern and prolonged period of relatively low accelerative forces required to obtain extremely high speeds, it is anticipated that "seat belt time" with movement around the cabin restricted will be longer than it is today.

The faster an aircraft travels, the hotter its exterior surface becomes from the friction of the atmosphere. Therefore, faster planes will have to travel at higher, more rarified atmospheres. The mach 3 airplanes will fly as high as 75,000 feet and mach 2 aircraft as high as 65,000 feet (Fig. 1). These extreme altitudes will necessitate a pressurized cabin in which the cabin atmosphere will simulate a much lower altitude. It is anticipated that the maximum cabin altitudes in these airplanes will be 6,000 feet. Pressurization will need to be assured by superb engineering design, for exposure to the extreme external altitudes by depressurization will be disastrous to all passengers. At these altitudes, the protection afforded by oxygen masks of the type that can be donned by passengers will be inadequate.

At altitudes over 55,000 feet, little protection from irradiation is afforded by the effect of filtration of the relatively dense atmosphere at lower levels. Two types of irradiation penetrate from space. They are cosmic irradiation and the radiation resulting from solar flares. Fortunately, cosmic irradiation is negligible between 55,000 and 65,000 feet. During a transatlantic flight, a passenger on an SST will receive a much lower total body dosage from this source than from having a chest x-ray picture taken. However, solar flare activity is a cause of concern, for it is unpredictable and can cause excessive exposure. The next period of maximal activity will not be until about 1969, and it appears that flares give-

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ing 4 rem/hour (an excessive dosage) or more at 65,000 feet probably will occur less than twice a year. Of necessity, an SST will carry radiation monitoring systems and, when they indicate excessive exposure, the airplane will descend to lower altitudes or the flight will terminate. Temporary grounding of these transports because of solar flares will be worldwide rather than local, as with inclement weather.

**CONSIDERATIONS FOR CARDIOPULMONARY PATIENTS**

How do the special characteristics of SST travel affect the judgment of the physician in evaluating his patient's ability to use this mode of transportation? To be practical, the clinical evaluation of these patients cannot depend upon sophisticated, time consuming, highly technical laboratory techniques. However, utilizing these techniques, Tomashefski and his group tested both severe pulmonary and cardiac patients in an altitude chamber under conditions simulating airline travel. They found that difficulty occurred only in pulmonary patients with significant oxyhemoglobin desaturation or with severe impairment of ventilation which negated the ability for compensatory hyperventilation at altitude.

An adequate office practice technique described previously for subsonic air travel can be applied here. The physician uses a general physical examination oriented to assess the patient's ability to perform some degree of physical activity comfortably at ground level. He also frequently uses an ECG, a chest x-ray film, a blood count, and an estimate of the patient's electrolytes and CO₂ combining power (Table 2). With this information, he can arrive at a decision about the work tolerance and physiologic function of the heart and the respiratory apparatus. Then the physician can classify his patient according to the method recommended by the Committee on Physiologic Therapy of the American College of Chest Physicians. This classification uses arbitrary subdivisions of cabin altitude or 2,000 feet. The physician arrives at a decision about the maximum cabin altitude to which his patient can be exposed. It can be seen that at the proposed SST cabin altitude, a maximum of 6,000 feet, most ambulatory pulmonary patients, including those with some degree of cyanosis, can travel with relative impunity (Table 3). Even severely affected patients with

![Figure 1](http://journal.publications.chestnet.org/pdfaccess.ashx?url=data/journals/chest/21456/)
restrictive functional defects can fly at this altitude with supplementary oxygen.

However, patients with emphysema or obstructive respiratory diseases severe enough to cause blood oxyhemoglobin desaturation, respiratory acidosis and/or cor pulmonale probably should not use SST's because they could not be given supplementary oxygen in flight with safety. Patients with unstable functional changes in their respiratory apparatus, such as those with pneumonia or acute asthma, should postpone all travel including use of SST until after recovery.

As for the evaluation of cardiac function, the proposed SST cabin altitude ceiling would appear to be acceptable to most ambulatory, stable cardiac patients (Table 4). If necessary, supplemental oxygen could be used. Cardiac patients with recent myocardial infarctions, status angina pectoris or any degree of heart failure also should be excluded from travel of this type.

It will be possible to travel long distances around the earth's surface in SST's. In crossing 15 meridians of latitude, the passenger gains or loses one hour depending upon the direction of travel. It would be possible in an SST to cross 180 meridians in one day, and at the point of destination, have the local time 12 hours out of phase with the time at the point of origin. Changes in time produce adverse effects because many body functions have rhythmic variations throughout the day. This is called circadian rhythm. The most striking example of this is the daily variation in the sleep-wake cycle. However, metabolic and endocrine functions also vary similarly, as witnessed by diurnal alterations in cortisol levels, growth hormone levels, and metabolic activity. The passenger must adjust to the new time cycle, and frequently it requires two to four days. He may need medication to aid in sleeping during the adjustment period.

With the maintenance of the cabin altitude at or below 6,000 feet, the only serious potential problem with the cabin atmosphere is that of low humidity. This can cause excessive drying of the secretions of the respiratory tract and its inherent, secondary problems. It is anticipated that artificial humidification in the SST's will be such that a reasonable humidity will be maintained. If this is the case, no problem from this source will exist.

Irradiation will cause no more adverse effects to the cardiopulmonary patients than to the healthy traveling passenger, and the anticipated protective as well as preventive measures appear to be adequate.

Several other considerations must be faced. The patient must need little more attention from the cabin attendants than the regular passenger. This principle is reinforced by the anticipated increase in "seat belt time" for SST travel, during which attention by the cabin crew will be limited.

If the patient's condition deteriorates in flight, the nearest definitive treatment centers are medical facilities on the ground. It is possible that the number and location of airports available for landing and debarking such a patient from an SST will be more limited than from the current subsonic transportation.

Finally, apprehension can cause an increase in respiratory effort and cardiac work. Confidence of the physician in the patient's ability to travel without adverse effects will do much to allay such anxiety. In addition, the high altitudes of SST flight will result in almost no air turbulence and, consequently, decrease tendencies toward motion sickness. This will also remove another cause for discomfort, effort, and concern.

**Summary**

1. The special characteristics anticipated for SST travel will have little effect on the

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**Table 4—Cardiac Patients**

<table>
<thead>
<tr>
<th>Cabin Altitude</th>
<th>Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>8,000 feet</td>
<td>Major cardiac disorders with adequate functional reserve at sea level</td>
</tr>
<tr>
<td>6,000 feet</td>
<td>Cardiac conditions where myocardial oxygenation is marginal</td>
</tr>
</tbody>
</table>
ability of most stable ambulatory, cardiopulmonary patients to use this type of transportation.

2. Severely impaired patients with obstructive lung disease, such as emphysema, who suffer from reduction in blood oxygenation, respiratory acidosis and/or cor pulmonale, cannot use supplemental oxygen with safety and should be restricted from this means of air travel.

3. Patients with dynamic and changing respiratory functions, such as those with pneumonia or acute asthma, would do best to postpone all travel including use of SST's.

4. Most cardiac patients will have little difficulty traveling on the SST because of the 6,000 feet maximum cabin altitude that is anticipated.

5. Cardiac patients with recent myocardial infarctions, status angina pectoris, or any degree of heart failure also are not candidates for travel of this type.

6. Whereas the flight pattern of these transports probably will require longer “seat belt time” (during which there will be less attendance from the cabin crew) and will have less availability for emergency landing facilities for hospitalization, the flights will be shorter, smoother and, in general, less exhausting to the ambulatory patient.

7. The possible passage over many time zones probably will require the patient to adjust his metabolic (circadian) cycle at his destination and produce some requirement for aid in readjusting his sleeping cycle.

8. In general, therefore, very little readjustment in the physician's approach to the travel of the ambulatory patient is expected with the advent of the SST.

RESUMEN

1. Las características anticipadas del vuelo en transportes supersónicos (TSS) permiten afirmar que la generalidad de los individuos con cardio-neumopatías estabilizadas pueden utilizar este modo de viajar.

2. Los sujetos con enfermedades respiratorias incapacitantes, como el enfisema con hipoxia, acidosis respiratoria o cor pulmonale, no pueden utilizar debidamente la oxygenación suplementaria y deben abstenerse de utilizar este medio de transporte.

3. Los pacientes con función pulmonar inestable, tales como los afectos de neumonia o crisis asmáticas harán bien en postponer el viaje.

4. La generalidad de los cardiopatías no experimentarán molestia alguna en el TSS, gracias a la presión barométrica equivalente a la de una altitud de 6.000 pies a que se mantiene la cabina de los aviones.

5. Este tipo de viaje es, por otra parte, contraindicado en sujetos con infartos recientes del miocardio, status anginoso o insuficiencia cardíaca en cualquier grado.

6. El modus operandi de estos transportes supone el uso mas prolongado del cinturón de retención (durante el cual se dificulta la atención por el personal del avión), así como menos facilidades para el aterrizaje de emergencia para la hospitalización. En cambio el viaje será más corto, suave y en general menos fatigoso para el paciente ambulatorio.

7. La posibilidad de pasar rápidamente de una a otra zona cronológica demanda una adaptación del ciclo metabólico al final del viaje y pude requerir asistencia en el reajuste del ciclo hípico.

8. En general no es de esperar que con el advenimiento del TSS se hagan necesarios cambios radicales en los conceptos vigentes relativos al viaje aéreo de pacientes ambulatorios.

RESUMÉ

1. Les caractéristiques particulières qui sont prévues pour les futurs voyages en transports supersoniaux n'auront qu'un petit effet sur la possibilité de les utiliser pour la plupart des maladies valides atteints d'affections cardio-vasculaires stables.

2. Beaucoup de malades atteints de troubles respiratoires de type obstructif, comme l'emplèse, qui sont atteints d'une diminution de l'oxygénation sanguine, d'acide respiratoire, de coeur pulmonaire, ne pourront pas utiliser avec sécurité le supplément d'oxygène nécessaire, ils ne devront pas être acceptés dans ce type de transports aériens.

3. Les malades atteints d'altérations de leur fonction respiratoire en crise, tels que ceux qui sont atteints de pneumopathie ou d'un accès d'asthme, auront intérêt à remettre tout voyage qui comporte l'utilisation de transports supersoniques.

4. La plupart des malades atteints de cardio-pathie auront une petite difficulté à voyager dans les transports supersoniques puisqu'on estime que la pression de la cabine correspondra à une altitude minimum de 2000 mètres.

5. Les cardiaki qui ont eu récemment un infarctus du myocarde, qui sont atteints d'angine de poitrine ou qui ont un certain degré d'insuffisance cardiaque, ne sont pas des passagers pour ce type de transport aérien.
ZUSAMMENFASSUNG


2. Durch obstruktive Lungenkrankheiten, wie Emphysem, schwer beeinträchtigte Patienten mit herabgesetzter Sauerstoffsättigung des Blutes, respiratorischer Acidose und Cor pulmonale werden nicht mit ausreichender Sicherheit durch die zusätzliche Sauerstoffversorgung versorgt und sollten daher von der Benutzung dieser Luftverkehrsmittel ausgeschlossen werden.

3. Patienten mit gesteigerten und wechselnden Lungenfunktionen wie bei Pneumonie oder akutem Asthma würden am besten alle Reisen, die Überschallflüge einschliessen, verschieben.

4. Die meisten Herzpatienten werden nur geringe Schwierigkeiten bei Überschallflügen haben, weil für die Flugcabine als Maximum eine Höhe von 6,000 Fuss vorgesehen ist.


6. Wenn auch die Flugbedingungen bei diesen Transporten längere "Anschallzeiten" (während der nur geringe Versorgung durch das Flugpersonal stattfindet) erfordern und wenig Möglichkeiten zu Notlandungen zur Überführung in ein Krankenhaus zulassen, so wird doch der Flug kürzer, sanfter und im allgemeinen weniger anstrengend für gefährliche Patienten sein.

7. Die eventuelle Passage über mehrere Zeitzonen wird wahrscheinlich erfordern, dass der Patient seinen Stoffwechselrhythmus am Bestimmungsort anpasst und vielleicht geringe Hilfe bei der Wiederanpassung des Schlafrythmus benötigt.

8. Im allgemeinen werden daher nur geringe Änderungen in der ärztlichen Einstellung zur Reisefähigkeit von gefährlichen Patienten bei der Enführung des Verkehrs mit Überschallgeschwindigkeiten erwartet.

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