Tolerance of Liver Transplant Patients to Strenuous Physical Activity in High-Altitude

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Physical functioning is improved after liver transplantation but studies comparing liver transplant recipients with normal healthy people are lacking. How liver (and other organ) transplant recipients tolerate strenuous physical activities is unknown. There are no data on the tolerance of transplant patients at high altitude. Six liver transplant subjects were selected to participate in a trek up Mount Kilimanjaro 5895m, Tanzania. Physical performance and susceptibility to acute mountain sickness were prospectively compared with fifteen control subjects with similar profiles and matched for age and body mass index. The Borg-scale (a rating of perceived exertion) and cardiopulmonary parameters at rest were prospectively compared with six control subjects also matched for gender and VO2max. Immunosuppression in transplant subjects was based on tacrolimus. No difference was seen in physical performance, Borg-scales and acute mountain sickness scores between transplant and control subjects. Eighty-three percent of transplant subjects and 84.6% of control subjects reached the summit (p = 0.7). Oxygen saturation decreased whereas arterial blood pressure and heart rate increased with altitude in both groups. The only difference was the development of arterial hypertension in transplant subjects at 3950 m (p = 0.036). Selected and well-prepared liver transplant recipients can perform strenuous physical activities and tolerate exposure to high altitude similar to normal healthy people.

Key words: Liver transplantation, physical performance

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Introduction

Four decades after the first human attempt (1), liver transplantation has evolved from a heroic extremely high-risk into an almost routine life-saving operation whose application is limited only by donor shortage (2). With excellent survival results, research on physical functioning and quality of life is likely to take increasing importance. Quality of life and performance level are altered by liver failure and improved by transplantation (2–4). However, studies comparing transplant patients with normal healthy subjects are lacking. In particular, the capacity to perform intensive physical activities has not been studied after transplantation of the liver or other organs. Tolerance to altitude and hypoxia and susceptibility of transplant patients to acute mountain sickness is unknown. To address these questions, a group of liver transplant and matched healthy subjects participated in a trek up Mount Kilimanjaro (5895m), Tanzania. In addition, this study describes important information as to how to prepare and safely accompany a selected group of immunosuppressed liver transplant recipients to high altitude in a remote area.

Methods

Study design

Inclusion criteria were identical for liver transplant and control subjects: normal liver and cardiopulmonary function, <50 years, non sport professional and normal active lifestyle. Three male and three female transplant patients (age: 39 ± 5 years; mean body mass index: 21.7 ± 2.7kg/m²) participated. Maximal oxygen consumption capacity (VO2max) was 37.6 ± 4.5mL/min/kg. Transplantation had been performed 3.8 years (range: 2–5) prior to the study because of primary sclerosing cholangitis (n = 2), hemangiendothelioma (n = 1), polycystic liver (n = 1), acute toxic liver failure (n = 1) or hepatitis C (n = 1).

Transplant subjects were prospectively compared with fifteen control subjects (three female/twelve males) matched for age (42 ± 5 years; p = 0.15) and body mass index (23.3 ± 2.8kg/m²; p = 0.12). Maximal altitude reached and reasons for abandon were recorded. The Lake Louise acute mountain sickness score (5) was calculated (range of possible scores, 0 to 24, with higher scores indicating greater disease; Table 1). Medical problems encountered were recorded.
Table 1: Description of the climb, success rate\(^1\), Borg-scale\(^2\) and Lake Louise acute mountain sickness score\(^3\) in transplant and control subjects

<table>
<thead>
<tr>
<th>Days</th>
<th>Camp</th>
<th>Altitude reached (m)</th>
<th>Distance covered (±1 km)</th>
<th>Duration of the climb (± 0.5 h)</th>
<th>Success rate</th>
<th>Borg-scale</th>
<th>Lake Louise acute mountain sickness score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transplant</td>
<td>Control</td>
<td>Transplant</td>
<td>Control</td>
<td></td>
<td>Transplant</td>
<td>Control</td>
</tr>
<tr>
<td>Machame checkpoint</td>
<td>1800</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Day 1</td>
<td>Machame</td>
<td>2980</td>
<td>18</td>
<td>7</td>
<td>6/6</td>
<td>15/15 (NS)</td>
<td>12.3 ± 2.22 (NS) 12.0 ± 4.2 (NS) 1.2 ± 0.7 1.4 ± 1.7 (NS)</td>
</tr>
<tr>
<td>Day 2</td>
<td>Shira</td>
<td>3840</td>
<td>9</td>
<td>6</td>
<td>6/6</td>
<td>15/15 (NS)</td>
<td>11.2 ± 1.3 11.6 ± 2.8 (NS) 1.0 ± 0.9 1.8 ± 1.4 (NS)</td>
</tr>
<tr>
<td>Day 3</td>
<td>Barranco</td>
<td>3950</td>
<td>4.5</td>
<td>3</td>
<td>6/6</td>
<td>15/15 (NS)</td>
<td>13.8 ± 2.2 13.6 ± 2.3 (NS) 3.5 ± 1.4 4.1 ± 3.1 (NS)</td>
</tr>
<tr>
<td>Day 4</td>
<td>Karanga</td>
<td>4150</td>
<td>6</td>
<td>4</td>
<td>6/6</td>
<td>15/15 (NS)</td>
<td>12.8 ± 1.6 11.8 ± 2.2 (NS) 3.3 ± 2.3 2.5 ± 1.9 (NS)</td>
</tr>
<tr>
<td>Day 5</td>
<td>Barafu</td>
<td>4550</td>
<td>4.5</td>
<td>3</td>
<td>6/6</td>
<td>15/15 (NS)</td>
<td>12.7 ± 2.7 13.8 ± 2.2 (NS) 2.5 ± 2.6 2.1 ± 1.2 (NS)</td>
</tr>
<tr>
<td>Day 6</td>
<td>Uhuru peak</td>
<td>5896</td>
<td>1</td>
<td>1</td>
<td>7/7</td>
<td>11/13 (NS)</td>
<td>12.2 ± 2.6 13.0 ± 2.6 (NS) 3.4 ± 3.4 6.6 ± 4.1 (NS)</td>
</tr>
<tr>
<td>Day 7</td>
<td>Mweka gate</td>
<td>3100</td>
<td>8</td>
<td>4</td>
<td>6/6</td>
<td>15/15 (NS)</td>
<td>13.2 ± 2.8 13.2 ± 3.0 (NS) 1.0 ± 1.5 1.9 ± 1.9 (NS)</td>
</tr>
<tr>
<td>Day 7</td>
<td>Mweka</td>
<td>1600</td>
<td>8</td>
<td>4</td>
<td>6/6</td>
<td>15/15 (NS)</td>
<td>1.0 ± 1.7 1.1 ± 1.9 (NS)</td>
</tr>
</tbody>
</table>

\(^{1}\)Success rate is defined as percentage of subjects reaching a given camp/altitude.

\(^{2}\)For calculation of the Borg-scale, subjects were asked to rate the intensity of exertion: a score of 6 indicates no exertion at all, 7 extremely light, 9 very light, 11 light, 13 somewhat hard, 15 hard, 17 very hard, 19 very, very hard, and 20 maximal exertion.

\(^{3}\)For calculation of the Lake Louise acute mountain sickness score, subjects were asked five questions about the following symptoms: headache; gastrointestinal upset; fatigue, weakness, or both; dizziness, lightheadedness, or both; and difficulty sleeping. Subjects were then assessed clinically for three symptoms: a change in mental status; ataxia; and peripheral edema. The response to each of the eight items was rated with a 4-point scale (0: no symptoms; 1: mild symptoms; 2: moderate symptoms; 3: severe symptoms). The total score is the sum of the individual scores for the eight items.

\(^{4}\)One transplant subject abandoned the trek at 4550 m due to physical exhaustion.

\(^{5}\)One control abandoned the trek at 4550 m due to a gastroenteritis and another at 5700 m due to high-altitude cerebral edema. They were rescued by two control subjects who were not eligible for calculation of the success rate at the summit.

\(^{6}\)p = 0.1 vs. transplant.

NS: nonsignificant difference control vs. transplant subjects.

Of the fifteen control subjects, six also matched for gender and VO2max (36.9 ± 7mL/min/kg; p = 0.42) served as a control for measurement of arterial blood pressure, heart rate, and oxygen saturation, daily at rest. The Borg-scale (6), a rating of perceived exertion (range of possible scores, 6 to 20, with higher scores indicating greater exertion; Table 1) was assessed daily. Heart rate and oxygen saturation were measured with a pulse oximeter (PalmSat 2500 Pulse oximeter, Chinook, Durango, CO, USA). Blood pressure was measured using a sphygmomanometer with a cloth cuff.

Independent Student’s t-, non-parametric Mann–Whitney U-, Chi-square and Fisher’s exact tests were used as appropriate and a p value inferior to 0.05 was considered significant. The study was approved by the institutional review board and all subjects provided written informed consent.

**Preparation, medication and diet**

In all subjects, physical preparation started 6 months before the study and consisted of aerobic training three times weekly with a gradually increasing intensity from 40% to 80% of the maximum heart reserve. In transplant subjects, immunosuppression was with tacrolimus (n = 2) and tacrolimus plus azathioprine (25 mg/day) (n = 4). The tacrolimus level was 6.5 ng/mL (range: 5–8). Prevention of acute mountain sickness consisted of oral acetazolamide 250 mg twice daily in controls, and salmeterol aerosol 125 μg twice daily and oral dexamethasone 1.5 mg every 4 h during the last ascent in transplant subjects. In addition, oral piracetam 4.8 g daily was given to all subjects. Infection prophylaxis was with daily atovaquone 250 mg and proguanil chlorhydrate 100 mg during and 7 days after the trek in all subjects (malaria). All subjects received inactivated hepatitis A vaccine and Vi-antigen-based vaccine for typhoid fever and booster vaccination for tetanus, diphtheria and poliomyelitis (inactivated vaccine) when indicated. Control but not transplant subjects received the yellow fever live vaccine. Insect repellents containing N,N-diethyl-3-methylbenzamide were used in all subjects. Levofloxacin 250 mg daily was given to transplant subjects as prophylaxis for traveller’s diarrhea. A hypercaloric diet (5000 kcal daily) made of sugars and proteins and including three meals and high-energy bars, and abundant hydration (4 liters/day) were administered.

**The climb**

The subjects covered approximately 80 km and ascended from 1800 m to 5895 m in a 6-day period (Table 1). The climb started at Machame checkpoint (1800 m). Subjects reached the altitude of 2980 m on day 1, and 3840 m on day 2. Day 3 was an acclimatization day (walking high, 4630 m, and sleeping low, 3950 m). Day 4 was an extra-acclimatization day at 4150 m. On day 5, the subjects reached 4550 m and left for the summit bid at 11:00 pm. The ascent to the summit (5895 m) was followed by a descent to 3100 m on day 6 and to 1600 m on day 7. Temperatures were initially those of the equatorial rain forest (∼30 °C) and decreased with altitude to freezing temperatures particularly at night and above 3000 m. Weather conditions were usual for the season except for the first day (heavy rains) and the summit bid (strong, freezing winds ~6–8 m/s; temperature ~30 ºC). Medical assistance, oxygen, high pressure chambers and a mobile pharmacy were available.

**Results**

**Physical performance (Table 1)**

All subjects reached the last camp (4550 m) on day 5. At this point, one control and one transplant subject abandoned the study due to gastroenteritis in the former and physical exhaustion and lower oxygen saturation in the latter. The other five transplant subjects reached the summit (Figure 1). Of the 14 remaining control subjects, 11 reached...
Five liver transplant patients reached Uhuru peak, the roof of Africa (5895 m), on February 20, 2003 at 05:41 am. The team had left the last camp Barafu at 11:00 pm instead of midnight because we thought that transplant trekkers would climb slower, but this was not the case and they arrived at Uhuru peak before the sunrise.

The summit, one abandoned at 5700 m due to severe neurological symptoms of high-altitude cerebral edema, and two rescued her. No difference in the summit success rate was seen between transplant and eligible control subjects: 5/6 vs. 11/13; p = 0.7. Borg-scales reached their highest values during the last ascent but no difference was seen between transplant and control subjects (17.2 ± 1.6 vs. 18 ± 2.6, respectively, p = 0.23).

**Acute mountain sickness (Table 1)**

In all subjects, acute mountain sickness scores increased with altitude and reached a first peak (>3) on day 3 at 3950 m. The scores decreased during the following two acclimatization days and leveled out (<3) on day 5 at 4550 m, before attaining a second peak at the summit (>3). No differences were seen between transplant and control subjects except for a lower score in transplant (3.4) vs. control subjects (6.6; p = 0.1) at the summit. During the summit bid, severe acute mountain sickness (high-altitude cerebral edema) developed in one control subject and required descent and oxygen therapy.

**Other medical problems**

One transplant subject (later diagnosed with relapsing hepatitis C) presented episodes of hunger, palpitations, eructations, and sweating that disappeared with oral glucose and that are suggestive of a hypoglycemia-induced autonomic response. Due to the circumstances (wilderness, remote area, suboptimal hygiene, high altitude) no blood sugar analysis could be performed. Severe gastroenteritis developed in three controls and responded to empirical treatment with levofloxacin in two and azithromycine in one. Cornea freezing was encountered in one transplant and two control subjects but resolved spontaneously with descent and left no sequelae.

**Cardiopulmonary parameters**

Oxygen saturation gradually decreased with increasing altitude in transplant and control subjects, but no difference between these groups was observed (Figure 2). There was a progressive increase in heart rate with altitude but no difference was found between transplant and control subjects (Figure 3). Arterial blood pressure increased with altitude in all subjects (Figure 4). Diastolic pressure was higher in transplant than in control subjects particularly at
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A major hurdle when climbing Kilimanjaro is the acute exposure to high altitude and hypoxia that may cause acute mountain sickness, high-altitude brain and lung edema (10). Prior to this study, no data were available on the tolerance of transplant patients to altitude and an important concern was as to whether neurotoxic calcineurin-inhibitors (11) would affect susceptibility to acute mountain sickness. Indeed, calcineurin-inhibitors cause functional and organic cerebral disorders and some of their side-effects (11) (headache, dizziness, ataxia) are undistinguishable from acute mountain sickness. Before proposing this study, the first author climbed Kilimanjaro twice, once without and once with tacrolimus therapy and noted no difference in acute mountain sickness score (data not shown). Daily recording of acute mountain sickness scores showed no greater susceptibility to high-altitude sickness in transplant subjects. High-altitude cerebral edema was encountered in one control subject, but in none of the transplant subjects. Altogether these data demonstrate that transplant recipients are not more vulnerable to acute mountain sickness despite being exposed to potentially neurotoxic calcineurin-inhibitors. It is important to note that the tacrolimus level was low (6.5 ng/mL; range 5–8).

A weakness in the analysis is that transplant and control subjects received different preventions for acute mountain sickness and caution should be used when comparing these two groups. Acetazolamide (an FDA-approved prophylaxis of acute mountain sickness) was given to controls (10,12). The simultaneous use of acetazolamide and cyclosporine has been reported to lead to a marked increase in the blood level of cyclosporine (13). The reasons for that interaction are not clear. There are no reports on the effect of acetazolamide on the pharmacokinetics of tacrolimus, but given the similarity of these two molecules and their usually similar pattern of drug interaction we elected not to use acetazolamide in stable tacrolimus-treated transplant subjects. Dexamethasone, an alternative for prevention of acute mountain sickness in people with intolerance to acetazolamide (10), was therefore used in transplant subjects. To reduce side-effects, dexamethasone administration was limited to the summit bid and doses lower than those usually recommended were given, which nevertheless might explain the trend in lower acute mountain sickness scores in transplant subjects during the last ascent compared with acetazolamide-treated controls. During the rest of the trek, salmeterol was given to transplant subjects based on a recent study (14) proving its efficiency in preventing high-altitude pulmonary edema and in ameliorating acute mountain sickness scores. Finally, piracetam was given to all subjects based on the previously documented neuroprotective effects against hypoxia (15–17), and the absence of side-effects and interaction with other medications. There is some evidence that ginkgo biloba is

Discussion

Liver transplantation improves quality of life, but little is known about the exact physical capacity of liver transplant recipients (2–4). Apart from anecdotal reports of highly select sport professionals returning to competition after transplantation (http://www.chrisklug.com) there are no controlled data on how ordinary transplant recipients tolerate extreme physical conditions and how their performance compares with normal healthy subjects. Whether having undergone heavy surgery and being chronically immunosuppressed limits the performance of strenuous physical activities in stress conditions is unknown. In addition, tolerance of transplant patients to altitude and hypoxia and susceptibility to acute mountain sickness are unknown.

That five out of six transplant subjects reached the summit of Kilimanjaro is a remarkable performance as a success rate of 60% is reported for ordinary trekkers. The only known unpublished experience of a transplant patient reaching the summit of Kilimanjaro is by a heart transplant patient (www.adrenalineadventures.net/news/351.html). Difficulties of this climb must not be underestimated: of approximately 20 000 trekkers every year, about ten succumb (http://news.nationalgeographic.com/news/2002/11/1115021115_KilimanPorters.htm). Climbing Kilimanjaro requires a highly demanding physical effort in a progressively hypoxic environment: in a 6-day period, trekkers ascend from 1800 m to 5895 m and cover ~80 km. The intensity of the physical activity and the corresponding energy consumption are best reflected by Borg-scale (6) (rate of perceived exertion) values of near-to-18 indicating extremely strenuous activity and by a weight loss of ~3% (data not shown) despite taking a hypercaloric diet. Although the Borg-scale is a subjective rating of perceived exertion, it correlates with objective physiological parameters of exercise intensity such as heart rate, circulating lactate, and oxygen consumption (7). Therefore the observation that the Borg-scale values were similar in transplant and control subjects shows not only that the transplant subjects did not experience more physical difficulty than the controls, but also that their degree of physical fitness and physiological tolerance to exercise is comparable to normal healthy subjects. Finally the success rate in reaching the summit was not different between transplant and control subjects and this is additional evidence that the physical performance of the transplant subjects was undistinguishable from that of comparable normal healthy subjects. Altered physical performance has been reported in transplant patients chronically exposed to steroids (8) and who present modifications in body fat distribution, weight gain, altered muscle and bone (9). But patients in our study received no steroids, thereby suggesting that the level of physical functioning is not altered by immunosuppressive regimens devoid of steroids.

3950 m (p = 0.036) and 4150 m (p = 0.047) and exceeded 90 mmHg. This was treated with nifedipine and tacrolimus dose reduction.
efficient in preventing acute mountain sickness (10) and we were aware of one kidney transplant ranger on Mount Denali taking cyclosporine A and ginkgo biloba (P. Hackett, personal communication, November 2002). However, we did not use ginkgo biloba due to the absence of data on interference with tacrolimus and the report of bleeding in a transplant patient exposed to this herbal medicine (18).

The observation that transplant patients tolerate high altitude similar to controls (taking into account the difference in prophylaxis) is important given the increase in number of transplant patients who may contemplate traveling to high altitude for recreational or economical purposes. Based on this study there should be no reason for physicians-in-charge to advise otherwise healthy transplant recipients against traveling to high altitude, providing appropriate prophylaxis of acute mountain sickness, as outlined in this study, is given.

Expected changes in cardiopulmonary parameters were seen in response to altitude: oxygen saturation decreased whereas heart rate and arterial blood pressure increased. Interestingly, these changes followed an identical pattern in transplant and control subjects. High-altitude tachycardia and increased arterial blood pressure are caused by acute exposure to hypoxia (19) and are thought to result from increased sympathoadrenal (20) activity; a modification in baroreceptor sensitivity (21), stress and environmental factors (low temperature, lifestyle modification) may also play a role. The only difference between transplant and control subjects was a higher arterial blood pressure in the former at all time points, culminating in the development of arterial hypertension at 3950 m. Higher arterial pressure in transplant subjects is probably a consequence of chronic exposure to nephrotoxic calcineurin-inhibitors (22). However, this hypertension remained moderate and responded to treatment with nifedipine and tacrolimus dose reduction. Nifedipine had not been used as a primary prevention of acute mountain sickness but was selected as an anti-hypertensive medication given its documented effect against high-altitude pulmonary edema (10) and possible prevention of frostbite.

Prior to this study no data were available on the effect of liver function on adaptation to altitude, but there were reasons to believe that an intact liver is essential for a normal acclimatization: first, the liver plays a central role in glucose homeostasis and increased glucose utilization at rest and during exercise is observed at altitude (23–25); second, liver diseases are often associated with pulmonary (26) and cerebral (27) disorders that may aggravate susceptibility to acute mountain sickness. Interestingly, one transplant trekker – who abandoned his progression at 4600 m due to presumed episodes of hypoglycemia, lower oxygen saturation, and eventually physical exhaustion – was diagnosed with recurrent hepatitis C on a biopsy done immediately after the study. Albeit clinically and biologically silent and compatible with normal activities at sea level, recurrent liver disease probably impaired adaptation to exercise in altitude. Reduced performance in this patient is also consistent with reports that hepatitis C reduces performance post-transplant compared with transplantation for other reasons (28). All transplant subjects had normal liver function tests immediately after the study (with the exception of the patient with hepatitis C who had mild transaminiase elevation) consistent with the observation that altitude does not influence liver enzymes (29) (data not shown).

Transplant patients are usually discouraged to travel into remote areas particularly when hygienic conditions are suboptimal, given the risks of infection. This was another point of concern given the location of the study (East-Africa) and the condition of wilderness inherent in the climb. In addition stress conditions encountered during climbing (high altitude, intense exercise, hypothermia) cause immunosuppression (30,31) and may increase the risk of infection. However, no infection was seen in transplant subjects. Levofoxacine was efficient in preventing traveller’s diarrhea as no cases were seen among the transplant subjects whereas three cases developed in controls (not taking levofoxacine) and caused one to abandon the trek, suggesting that levofoxacine should be considered in immuno-competent trekkers submitted to stress conditions and suboptimal hygiene standards. Although the likelihood of arthropod bites and developing yellow fever and malaria above 1200 m is minimal, it was crucial that protection against these diseases be maximal in transplant subjects. The yellow fever live vaccine, recommended by WHO in normal healthy people, was contra-indicated in transplant subjects (32). Instead, insect repellents containing N,N-diethyl-3-methylbenzamide were used (33). Atovaquone and proguanil chlorhydrate are well tolerated and do not interfere with calcineurin-inhibitors and therefore were given for prevention of malaria. This study suggests that transplant patients taking light immunosuppression should not necessarily be advised against participating in recreational activities in far-off countries providing adequate infection prophylaxis is given and medical assistance is available.

Climbing Kilimanjaro is not feasible in all transplant patients and the six subjects in the study represent a selected group and were very well prepared and conclusions reached should not be generalized to all liver recipients in that they are such a diverse group of patients with different physical constraints pre- and post-transplant. Age was arbitrarily limited to 50 years; they had been transplanted at least 2 years before the study and had fully recovered from the peri-transplant period. However, they had not necessarily had an easy post-transplant course and one had even received two grafts (data not shown). A wide range of liver diseases (acute/chronic, viral/non-viral, tumoral/non-tumoral) were represented. The type of immunosuppression was not an inclusion criterion in the study and the fact that immunosuppression was light and without steroids simply reflects general practice after liver transplantation.
They had normal liver and cardiopulmonary function and were physically and socio-professionally rehabilitated, a result increasingly achieved by transplantation (2). The important point made by the study is that the performance of these transplant patients was identical to that of comparable healthy subjects.

A complementary aim of this expedition is to increase awareness regarding the value of organ donation. Public and physicians attitude toward organ donation and transplantation depends upon their knowledge of the field and erroneous perceptions may critically affect the availability of donor organs (35). Therefore we hope that diffusion of this expedition, by disseminating unequivocal evidence of the excellent rehabilitation that a donated organ confers on its recipient, may increase the supply of organs for transplantation (36). Of note, we observed a substantial increase in donor rates in our region during the weeks of maximal publicity associated with this climb (data not shown).

In summary, this study demonstrates that selected liver transplant patients can perform demanding physical activities in extreme conditions with a similar degree of success as in normal healthy controls. Transplant patients show no difference in cardiopulmonary response to altitude and are not more susceptible to acute mountain sickness. The only patient whose performance was lower was retrospectively diagnosed with recurrent hepatitis C suggesting that an intact liver is essential for adaptation to exercise in altitude. In conclusion, this study provides the first unequivocal evidence that having undergone major abdominal surgery and being chronically exposed to steroid-free tacrolimus-based immunosuppression does not reduce the level of physical functioning in well-selected and well-prepared liver transplant recipients.

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Caution. Given the risks at stake this type of trek is not recommended to transplant patients unless they are properly selected, prepared and guided by a medical team experienced in transplantation and mountain medicine and assisted by professional mountaineers.

References

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