jhum, farmers introduced tea cultivation in some areas of district.

To estimate soil organic carbon (SOC) stock under different land uses, random sampling was done in the district and 100 soil samples were collected from 0 to 30 cm depth. SOC stock was calculated by multiplying SOC concentrations with bulk density (BD) and thickness of the soil layer. To assess the statistical differences among soil properties, One-way ANOVA test was conducted followed by the Duncan's test ($P < 0.05$). Data presented in Table 1 show significant influence of land-use systems on BD. One-way ANOVA revealed significant differences in BD values ($F = 3.924$, $P = 0.005$). The value of BD ranged from 0.82 to 0.98 g/cm^3. Tea gardens had the highest value and fallow jhums had the lowest value of BD. SOC was found to be highest in tea garden soils, followed by forest soils. However, fallow jhum had the lowest value of SOC and no statistical difference was observed. Figure 1 presents data pertaining to SOC stock under different land uses. SOC stock was significantly influenced by land uses at both the depths. In surface soils, maximum (36.62 t C per ha) value of SOC stock was found in tea garden soil, which is statistically comparable with forest soils (32.56 t C per ha). However, fallow jhum soils had minimum (22.53 t C per ha) amount of SOC stock. The study showed that tea gardens are able to sequester more SOC in comparison to fallow/degraded jhum. An increasing trend in SOC and soil carbon stock under tea gardens suggests the acceptability of this new land use in comparison to fallow jhums. Moreover, this will not only provide improved nutrient cycling and protection of soil from exposure during the new jhum cycle, but also open up the possibility of fallow/degraded jhums as potential carbon sequestrations areas. It will also provide a solution from regular clearing and burning of vegetation, which will reduce anthropogenic carbon emissions and help mitigate climate change.

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Islet transplantation: the Indian perspective

In continuation of the comprehensive review on clinical islet transplantation by Saravanan *et al.*[1] that focuses on the global scenario, it is appropriate to consider this important issue in the Indian context. The advantages and safety of islet transplantation in selected patients with type-1 diabetes mellitus (T1DM), experiencing life-threatening episodes of severe hypoglycaemia and in patients undergoing total/partial pancreatic resections, have been well demonstrated in the western as well as in certain Asian countries. Such transplantation is recognized by their national health systems and is reimbursable by their insurance systems[2].

Recent statistics from the International Diabetes Foundation denotes that China with about 100 million and India with about 78 million house the highest number of diabetics in Asia[3]. Amongst total diabetics, T1DM constitutes 10%, affecting young individuals. According to the sixth edition of the International Diabetes Federation diabetes atlas, India accounts for most of the children with T1DM in Southeast Asia, and has three new cases of T1DM/100,000 children in the 0–14 age group[4]. According to WHO projections, India would have 100 million diabetics by 2030 with as many as 10 million individuals with T1DM. Patients with T1DM experiencing life-threatening episodes of hypoglycaemic unawareness are reported to be benefited by islet transplantation.

Diabetes associated with pancreatic exocrine diseases such as chronic pancreatitis classified as type-3c diabetes (T3cDM) by the American Diabetes Association, is of relevance here. It was earlier misdiagnosed as either type-1 or type-2 diabetes, but is now recognized to be a distinct entity in terms of clinical presentation and pathophysiology. This form of diabetes is brittle in nature because of hepatic insulin sensitivity and lack of pancreatic polypeptide response. Since there is no prevalence data, T3cDM is considered to contribute to 4–5% of total diabetics, according to the global working estimate[5]. The prevalence of idiopathic chronic pancreatitis (ICP) is comparatively higher in India; consequently the occurrence of T3cDM would be more. The excruciating pain perceived in the patients draws clinical attention, and those who fail to respond to medical and endoscopic treatments are advocated resection of the pancreas to alleviate pain, which fail to respond to medical and endoscopic treatments. In such patients, autologous islet transplantation is performed to prevent loss of β-cell mass in order to prevent/minimize the occurrence of diabetes.

An initial population-based study in Kerala, confirmed later by a questionnaire-based study in the Asia-Pacific region, has recorded the prevalence of ICP to be 114–200/100,000 individuals in southern India, which is markedly higher than in western and industrialized nations (10–15/100,000). Importantly, patients report initially with diabetes and are then diagnosed for ICP with the mean age of diagnosis being less than 30 years. However, it is noted that about 30–40% of patients with ICP develop diabetes; more than 50% of these individuals will develop diabetes before 40 years of age[6].

In comparison to the western countries, wherein it takes about 10 years for diabetes to manifest in diagnosed CP patients, in India it manifests within 2 years after diagnosis of ICP, indicating the rapid loss of endocrine functions in these individuals. It is considered that 5–10% of total diabetics in India are affected by T3cDM, with about 3.5–7 million individuals requiring effective therapeutic management. In summary, T3cDM that affects younger individuals at the prime of their life poses not only serious clinical challenges, but also augurs immediate measures for its management.

Considering the above facts, we have been working to establish safety and feasibility of islet transplantation in India for the past eight years. We have developed expertise and conducted studies with non-human primates[7], apart from optimizing protocols related to isolation and characterization of clinical-grade islets[8]. Since autologous islet transplantation for patients with chronic pancreatitis has become the standard of care in several western countries, we initiated human autologous islet transplantation studies with due approvals obtained from DCGI-recognized Institutional Ethics Committee and Institutional Committee for Stem Cell Research, in patients with chronic pancreatitis who were posted for distal pancreatectomy for pancreatic ductal stricture with refractory pain. Over the study period of one year, we noted that circulating levels of insulin increased from 1.6 and 4.0 μU/ml to 24.4 and 27.2 μU/ml, and C-peptide levels from 0.9 to 4.0 ng/ml and from 2.6 to 3.7 ng/ml in these subjects without any adverse events. Our experiences in autologous islet transplantation in chronic pancreatitis patients undergoing partial pancreatectomy signify a step forward not only in the management of patients with ICP, but also in establishing the safety and efficacy of islet transplantation in our country[9]. Islet transplantation has indeed gained impetus after Shapiro *et al.*[10] modified the immunosuppressive regimen and demonstrated sustained insulin independence in T1DM patients. Thus, allogenic islet transplantation offers an attractive therapeutic option for patients who are on a immunosuppressive regimen, such as those who have undergone kidney transplantation.

Even though islet isolation protocols and immunosuppressive regimen have been optimized, challenges still exist, warranting intensification of research in this area. Despite increased awareness of organ donation and implementation of the Transplantation of Human Organ (THO) legislation, pancreas is not effectively utilized in cadaver transplantation programmes. Limited supply of pancreata from deceased multi-organ donors also calls for alternate sources of β-cells. Intense efforts are ongoing to establish stem cell-derived, insulin-secreting β-cells as an alternate source for cell therapy to treat diabetes in selected patients not responding to conventional insulin therapy. To date, these cell types have not entered into clinical practice. Secondly, liver is considered to be the most suitable site for transplantation at present. It is also known that 60% of transplanted islet mass is destroyed by blood-mediated inflammatory response. Considering that liver is a hub of metabolic activities, it is necessary to study related effects on islets transplanted into liver. The need for life-long immunosuppression in an allogenic setting has also to be surmounted for islet transplantation to become a standard of care in routine clinical practice. In this regard, efforts are on to protect islets from host immune system by encapsulating them and transplanting the islet-loaded devices. Nonetheless, the devices still encounter problems such as hypoxia-induced cell death, complement-activated inflammation, insufficient nutrition, etc. Again, none of these devices has been approved for human use. Recently, Encaptra device by an American company (Viacyte Inc, San Diego, California), which encapsulates embryonic stem cell-derived β-cells has entered into human clinical trials, the results of which are awaited. Although phenomenal progress has occurred in the last few years in islet transplantation strategies, the area still needs intense research for it to become a routine clinical practice. These include generating skilled manpower, establishing suitable infrastructure, including laboratories with GMP-certified facilities and increased utilization of pancreata from cadaveric sources. In India, concerted national efforts are to be initiated by healthcare professionals and policy makers towards establishment of a central facility where (1) islets can be isolated from cadaver pancreata obtained from different regions of the country, (2) characterization of the isolated islets can be performed to ensure suitability for transplantation and (3) human islets can be made available for research purposes. Further, such a facility can also conduct training programmes to develop human resources in the area as well as offer a platform for researchers to develop islet transplantation strategies to avoid immunosuppression.

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