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Original Article

The Start-Up of the first Hematopoietic Stem Cell Transplantation Center in the Iraqi Kurdistan: a Capacity-Building Cooperative Project by the Hiwa Cancer Hospital, Sulaymaniyah, and the Italian Agency for Development Cooperation: an Innovative Approach

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Abstract. We describe the entire process leading to the start-up of a hematopoietic stem cell transplantation center at the Hiwa Cancer Hospital, in the city of Sulaymaniyah, Kurdistan Iraqi Region. This capacity building project was funded by the Italian Development Cooperation Agency and implemented with the support of the volunteer work of Italian professionals, either physicians, nurses, biologists and technicians. The intervention started in April 2016, was based exclusively on training and coaching on site, that represent a significant innovative approach, and led to a first autologous transplant in June 2016 and to the first allogeneic transplant in October. At the time of reporting, 9 months from the initiation of the project, 18 patients have been transplanted, 15 with an autologous and 3 with an allogeneic graft. The center at the HCH represents the first transplantation center in Kurdistan and the second in wide Iraq. We conclude that international development cooperation may play an important role also in the field of high-technology medicine, and contribute to improved local centers capabilities through country to country scientific exchanges. The methodology to realize this project is innovative, since HSCT experts are brought as volunteers to the center(s) to be started, while traditionally it is the opposite, i.e. the local professionals to be trained are brought to the specialized center(s).

Keywords: Kurdistan, capacity building, bone marrow transplantation, global health.

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Introduction. Hemopoietic stem cell transplantation (HSCT), either autologous or allogeneic, is an effective treatment for many hematologic disorders. On a global basis, over 70.000 procedures are currently performed every year in more than 70 countries.[1] Unfortunately, due to economical and/or political constraints, not all the countries and geographical areas have enough resources and expertise to establish a HSCT program. This implies that in many countries patients are forced to emigrate when a transplant is needed, with heavy social and economic problems for their families and the governments.

The Hiwa Cancer Hospital (HCH) of Sulaymaniyah is a leading oncology institution in Iraqi Kurdistan. In 2015, the Institute for University Cooperation (ICU) of Rome identified this center as a possible target for a project of high-technology medical intervention addressed to the development of a HSCT center devoted to the treatment of malignant and non-malignant hematologic disorders, in particular thalassemia major, which represents a major problem in the country. A transplantation expert from Italy made a preliminary visit to the HCH, confirming the feasibility of a stem cell transplantation program. A capacity-building project was designed and submitted to the Italian Development Cooperation Agency (AICS), which approved its funding on March 2016.

Capacity building is the process by which individuals, organizations, institutions and societies develop abilities to perform functions, solve problems and set and achieve objectives.[2] In this paper we describe the entire process leading to the start-up of the Center, the results obtained 9 months after the start of the project and future perspectives. This is the first stem cell transplantation center established in the Kurdistan Region, and the second in Iraq. We conclude that international development cooperation may be of great value in the field of high-technology medicine and contribute to improved local centers' capabilities, through country-to-country scientific exchanges. Moreover, on-site training and coaching proves an effective innovative method to establish a sustainable activity in developing countries, as alternative to a more traditional methodology, where local professionals to be trained are brought to the specialized center(s) with higher expenditure and less predictable final results.

Methods. *Exploratory mission:* A relationship between the HCH and the ICU started in July 2015, when an Italian HSCT expert conducted an exploratory mission on behalf of ICU in order to ascertain the feasibility of a stem cell transplantation project at the HCH. A transplantation unit (TU) with positive pressure single rooms had been previously built in the HCH, thanks to a donation of the Regione Toscana, Italy, but the unit was never activated due in part to limited availability of adequate skills and in part to economic problems.

During the first visit, an appropriate grid, already successfully employed in other circumstances and containing all the necessary questions, was applied to verify the adequacy of the hospital itself and of all the necessary services that are normally involved in HSCT. The areas involved in the process were those listed in **table 1**. The director of HCH and most of the single-sector responsible physicians or administrators were interviewed. Inspections were also conducted to better ascertain the availability and functioning of instrumentations and devices. At the end of the visit, a positive evaluation was released, confirming the feasibility of a capacity building project for the start-up of a stem cell transplantation activity. A simplified scheme of our project is shown in **figure 1**.

Project definition and funding: The second step was designing the project. This was done according to a call for proposal (n. 10548/02/0) by the Italian Ministry for Foreign Affairs – General Direction for Development Cooperation. A capacity building project was submitted by ICU, approved and funded in December 2015. The assigned budget was € 329,000. The contribution of HCH itself to the financial plan consisted of existing instrumentation and laboratory facilities, but the HCH also provided for the accommodation of the volunteers for the whole duration of the project.

Unfortunately, still in the month of December 2015 a fire accident suddenly developed in the TU, due to malfunctioning of the air-treatment unit, with severe damage to the whole TU for a cost of approx. $ 200,000. Though this obviously

Table 1. Areas of the Hiwa Hospital that were explored in the preliminary assessmen. Hinari is a programme set up by WHO together with major publishers, that enables low- and middle- income countries to gain access to one of the world's largest collections of biomedical and health literature (http://www.who.int/hinari/en/).

Area	***Details***
Personnel	Responsibility tree Qualification Training needs for physicians, nurses, biologists, technicians
Specific clinical programs	Thalassemia, leukemias, lymphomas, myeloma
Transplant ward	Size of the unit and presumptive future activity Technology and functioning (HEPA) Instrumentation (pumps, emergency equipment,etc) Sanitation
Blood bank and immunohematology	Blood products available Laboratory tests (viral, immunehematology) Blood irradiation facility Leukocyte filters
Bone marrow harvest facility	Surgery room Anesthesiology and devices
Apheresis facility	Cell separator (s) and kits Collection and depletion expertize
Cell enumeration, manipulation and cryopreservation	Flow-cytometry instrumentation and expertise Monoclonal antibodies and other reagents Cell manipulation lab, with centrifuge and sterile hood Cryopreservation storage tank and -80 C°mechanical freezer
Central catheter insertion	Devices (atrial and femoral catheters) Insertion expertise.
Pharmacy and drugs	Preparation policy General drugs including antibiotics, antivirals, antifungals Chemotherapy drugs High-dose drugs for conditioning Immunosuppressants
Hardware and Software	PC and internet facility Electronic notes software
Medical library and internet connection	Hinary access

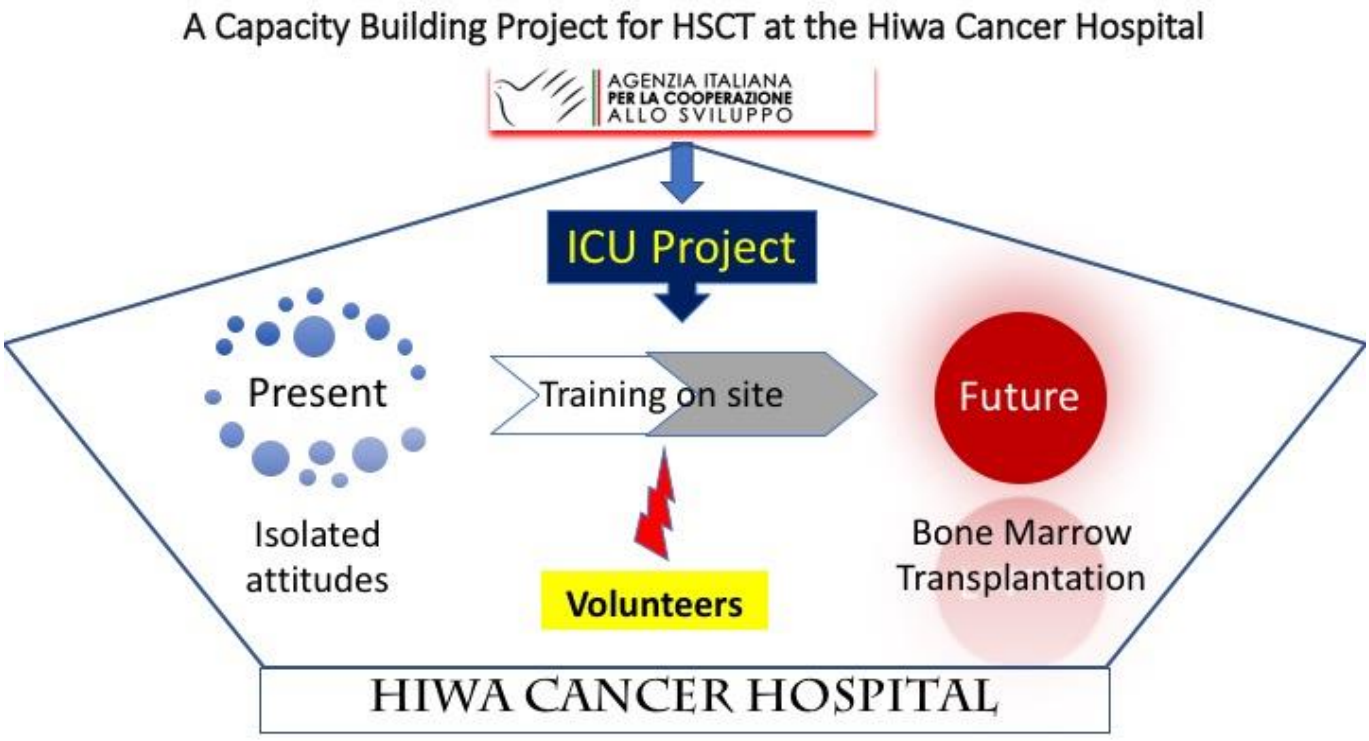

Figure 1. Schematic representation of the capacity building project at the Hiwa Cancer Hospital. Agenzia Italiana per la Cooperazione allo Siluppo Italian Agency for Development Cooperation (AICS).

represented a factor for a possible delay or even suspension of the project, the scientific advisor of ICU and the responsible for AICS prompted for a rapid restoration of the TU, that HCH started in April 2016. The delay was therefore minimal, and the team could begin the training activity the same month, while the restoration works were ended in July.

The capacity building process: To reach the target of a self-sustainable HSCT activity at the HCH, efforts were directed to the training of local personnel, in particular to perform functions, solve problems and set and achieve objectives.[2] The scientific advisor of the project also coordinated the volunteers who delivered training with lectures and seminars, and were also in charge of editing and verifying protocols, as well as of steering clinical work and coaching the local personnel. This was done by attending the morning patient tour and the afternoon outpatient clinic, or participating to the laboratory activities. The personnel involved in the HSCT program, either Italian and Kurdish, also attended the regular weekly activities, such as the morning briefings (every working-day), the weekly seminars on clinical and scientific issues, the transplantation meetings (once a week) with discussion of all the transplantation cases. The chairman of the transplantation meeting regularly took minutes that were regularly distributed to all participants.

Results. *Project start-up:* In April 2016, we decided to hold the preliminary training course addressed to doctors, nurses, biologists and technicians of the HCH. The course took approximately 3 weeks. A list of the covered subjects is reported in **table 2**. Editing and

Table 2. List of the subjects/titles covered by the initial educational meeting entitled "Hematopoietic Stem Cell Transplantation at Hiwa Hospital" held April 3-12, 2016. At the end of the course, all participants received a certificate and a copy of the power-point slides presented by the speakers.

1. History of HSCT and rationale
2. How to improve HSCT activity in emerging countries
3. Transplant indications in adults
4. Transplant indications in children
5. The HLA system in stem cell transplantation
6. Type of donor: identical sibling or other
7. Standard of care for thalassemia in Kurdistan
8. Preparation for BMT of thalassemia patients
9. A dedicated software for BMT in developing countries
10. Conditioning regimens
11. Engraftment and immunological reconstitution after HSCT
12. GVHD pathogenesis and prophylaxis
13. Acute GVHD
14. Chronic GVHD
15. GVHD staging system and treatment
16. Early complications
17. Late complications
18. Monitoring of chimerism
19. Post-HSCT follow-up
20. Transfusion support
21. ABO incompatibility in HSCT
22. Infection prophylaxis
23. Bacterial infections in HSCT
24. Fungal infections in HSCT
25. Viral infections and pre-emptive treatment
26. Cryopreservation and thawing
27. Management of fever in neutropenic patients and HSCT
28. Sepsis: changing scenario
29. Transplant practice in:
    a. Haemoglobinopathies
    b. Malignant lymphomas
    c. Multiple myeloma
    d. Myelodysplastic syndromes
    e. Chronic myeloid leukemia
30. Acute leukemias, adults and children
31. Aplastic anemia
32. Stem cell infusion
33. Chemotherapy: safe preparation and administration
34. Management of mucositis
35. Nursing support in acute and chronic GVHD
36. Monitoring vital parameters and alarm signs
37. Nursing the critically ill patient
38. Nutritional aspects
39. Special nursing issues:
    a. Venous access and PICC
    b. CVC management
    c. CVC Infections
    d. Management of extravasation
    e. Patient isolation rules and infection control
    f. Parents education
    g. Blood components: a standard for administration
40. Donor and recipient work-up
41. Stem cell target
42. Peripheral cell mobilization and collection
43. Marrow harvest procedure
44. Cell processing
45. Cryopreservation and thawing
46. Liquid-phase autologous transplantation
47. Essential hematology for nurses:
    a. Leukemia
    b. Lymphoma
    c. Multiple Myeloma
    d. Thalassemia and SCD
    e. Aplastic anemia
    f. The use of laboratory in hematology and transplantation
    g. Basic principles of chemotherapy
    h. Stem cells and their use in transplantation

Table 3. Protocols and procedures edited, verified and approved at the HCH by the joint efforts of Italian and Kurdish team. They are divided into 4 groups by the field of application. Some of them are accompanied by attachments as forms, calculation sheets, or algorithms to facilitate the use.

A) Collection and processing
- Take in charge of donor and stem cell collection
- Donor/patient clearance
- Release of product
- Processing of HPC-A
- Quality control on satellite vial
- Protocol of hemopoietic cells thawing
- Enumeration of CD34+ cells in the PB and apheresis product using true-count bead method
- Enumeration of CD34+ cells in the peripheral blood and apheresis (simplified protocol)
- Internal Quality Control IE Lab of Hiwa Hospital
- Collection Policy Typing Xmatch and Transfusion

B) Clinical Unit
- Proposal for Stem Cell Transplantation
- Donor work-up
- Recipient work-up
- Downstage of severe thalassemia
- Approach to fever in neutropenic patients
- Allogeneic matched sibling donor transplantation in patients with low-risk thalassemia
- High-dose melphalan for autologous transplantation in multiple myeloma (MEL200)
- BEAM for autologous transplantation in malignant lymphomas (BEAM)
- Progenitor cell mobilization with intermediate or high-dose cyclophosphamide (HD-CY) followed by G-CSF for autologous transplantation
- Reinfusion of peripheral blood or bone marrow stem cells
- Mobilization with GCSF only
- Bu-Flu for allogeneic transplantation in AML in older patient
- Bu-Flu for allogeneic transplantation in AML in young patient
- ATG-Cy for transplantation in aplastic anemia under 30
- ATG-Cy for transplantation in aplastic anemia between 30 and 40 y
- Bone Marrow Collection
- Bone Marrow donor follow up policy

C) Nursing
- Management of mucositis
- Management of CVC
- Diet advise after BMT
- Recommendations for the prevention and treatment of drug extravasation
- Use of vital chart, fluid balance chart and drug chart
- Pain assessment tools
- Nurse job description
- Nursing care plan focuses
- Nursing management of a_GVHD

D) Blood Bank
- Internal Quality Control
- Typing Policy Xmatch and Transfusion
- Donor and patient blood typing

verification of clinical and laboratory protocols dedicated to the transplantation program (**Table 3**) were conducted during the same period. The hospital provided the dedicated staff, and the director also drew an organigram depicting the responsibility tree. This led to a substantial modification of the organization, also to cope with existing international standards, as those defined by JACIE at http://www.jacie.org/standards.

The apheresis facility was the first to be started with 2 new-generation cell separators, a Fresenius Comtec, and an Amicus Fenwall device. A reliable and easy to use flow-cytometry double platform technique for CD34+ cell enumeration was assessed, based on a well-established methodology.[3] The manipulation laboratory and a technique for cell cryopreservation were set up by the Italian team and implanted in the HCH. A well-equipped transplantation sterile ward, with 6 HEPA-filtered, positive pressure, conditioned-air single rooms was already present and ready for use. At the beginning the cryopreservation was carried out by means of a -80°C mechanical freezer alone,[4] but later a fully equipped liquid nitrogen tank was supplied and cells were initially freezed in the -80°C to be later stored in the liquid phase of liquid nitrogen.

One month later, a series of patients underwent clinical selection procedures based on previously approved criteria and including age, general performance, organ function, disease phase and informed consent, and some of them were finally admitted for the stem cell collection and cryopreservation in view of the autologous transplantation. For stem cell mobilization, in patients with multiple myeloma we used a protocol with G-CSF alone (G-CSF 10 μg/kg/day until the CD34+ cell collection target was achieved, usually day 5), while in lymphoma patients harvest was done in the context of the advanced disease protocol itself. This was BeGeV[5] in Hodgkin lymphoma, DHAP in non-Hodgkin's lymphomas, always with addition of G-CSF 10 μg/kg/day since the end of chemotherapy to the day when CD34+ cell collection target was achieved. In some cases, also the intermediate-dose (2 to 4 g/m^2) cyclophosphamide mobilization protocol[6,7] was employed. Since in this phase of the program only single transplants were planned, a target of 5 x 10^6/Kg CD34+ cells was set, using

an algorithm to have an accurate collection prediction,[8] with an intention to increase the value as soon as the preliminary results would confirm us of the adequacy of the procedures in view of a double autologous transplantation program.

First autologous transplants: A first autologous transplant was carried out 3 months after the program was started in a multiple myeloma patient, using melphalan 140 mg/m^2 as high-dose regimen and peripheral blood stem cells (PBSC) as autograft. The engraftment was prompt without major complications. The following month another myeloma patient was successfully autografted, and the program was therefore set out with a series of candidates either with myeloma or malignant lymphoma. Since July, when the HSCT Unit restoration was completed, the transplants were all carried out in the new ward. The clinical characteristics of the patients and the data of stem cell collection, transplantation and engraftment are reported in **table 4**. There were 15 patients, 11 males and 4 females. Median age was 40 years (range 20 to 60). MM patients were 7, HL were 6 and NHL were 2. Status of disease was CR1 in 4, CR2 in 5, PR1 in 3 and SR in 2. Following the high-dose therapy, all the patients received G-CSF 5 mcg/kg to speed engraftment. All received antiviral and antifungal prophylaxis. The median number of CD34+ cells infused was 5.5 x 10^6/Kg (range 4.6 to 20.0). All patients fully engrafted but one who died with an acute heart failure on day+19 with granulocyte engraftment but without platelet engraftment. In this series, granulocyte engraftment ($\geq$0.5 x 10^9/L) occurred on (median) day +11 with a narrow range from 9 to 12. Platelet engraftment ($\geq$20.0 x 10^9/L) occurred on (median) day +12, range 10 to 17. Thirteen out of the 15 patients underwent a febrile complication, with or without bacterial isolation. Only one patient had a life-threatening complication, with intestinal perforation, but underwent a successful surgical intervention. Data on disease reevaluation are not presented as follow-up is currently too short. All patients but one are alive at a median of 75 days from transplant (range 15-223).

First allogeneic transplants: The initial allogeneic program was set up with the aim to offer a cure to the most frequent hematological disease in the region,[9] i.e. thalassemia.[10] More than one thousand patients with thalassemia live in the area of Sulaymaniyah, most of them are children belonging to large families and having therefore a high probability of a matched family donor. Patients eligible to transplant were considered those with low-risk characteristics (age $\leq$ 7 years, liver size $\leq$ 2 cm below costal margin) and a HLA matched sibling donor.[11,12] A downstaging protocol with hydroxyurea and deferoxamine or deferasirox was adopted in cooperation with the Thalassemia & Congenital Blood Diseases Center in Sulaymaniyah directed by LR. Conditioning regimen included iv busulfan and cyclophosphamide.[13] GvHD and rejection prophylaxis included ATG,[14] from day -12 to -10, and cyclosporin, methotrexate and methylprednisolone. The first allogeneic HSCT was performed on October 8th, 2016 and up to now overall 3 patients (2 females, 1 male) underwent HSCT. All of them received GCSF-primed bone marrow[15] from an HLA matched sibling. All donor/recipient couples shared the same blood group and were CMV concordant, i.e. all CMV positive. Engraftment occurred at a median time of 17 days. No major complications were observed in the early aplastic phase after HSCT. One patient developed grade II aGvHD and other potentially life-threatening complications (CMV enterocolitis, low grade microangiopathy, PRES) which resolved with proper treatment. All three patients have been already discharged at home (on day +25, +27 and +96, respectively); they are alive and well, continuing immunosuppression. Two of them are already transfusion independent, the third, though full donor chimera, having just recovered from many complications, not yet.

Discussion. Iraqi Kurdistan first gained autonomous status in 1970 following an agreement with the Iraqi government, and was re-confirmed as an autonomous entity in 2005. The region has considerable oil and mineral resources. However, due to the current conflict with the Islamic State, with more than a million Syrian and Iraqi refugees seeking shelter in the Kurdish territory, and also due to the fall of oil price, since 2012 the country entered a deep economic crisis that also involved the health system. The Italian Ministry of Foreign Affairs, through the AICS, is regularly supporting the Kurdish population also with health and social projects.

Table 4. Autologous transplantation: characteristics of the patients, time to engraftment and survival.

							Cell count recovery x 10^9/L (+days)								
Pt.	Sex	Age (years)	Disease	Disease status at HSCT	Conditioning Regimen	CD34+ x 10^6/kg	PMN ≥0.5 x10^9/L	PMN ≥1.0 x10^9/L	PLT ≥20 x10^9/L	PLT ≥50 x10^9/L	PLT ≥100 x10^9/L	Days of fever >38	PLT transf (units)	RBC transf (units)	Survival after HSCT (+days)
1	M	40	MM	CR1	MEL140	4.6	11	12	15	17	27	2	2	2	223
2	M	59	MM	CR1	MEL140	5.2	12	13	14	31	52	1	5	2	193
3	F	53	MM	CR1	MEL140	5.0	11	13	11	18	26	1	1	1	176
4	M	33	NHL	PR2	BEAM	5.1	11	12	17	44	67	11	5	6	162
5	M	36	HL	CR2	BEAM	13.0	10	11	10	13	15	2	1	0	155
6	M	46	MM	CR1	MEL200	5.7	11	12	12	16	31	1	1	0	122
7	M	57	MM	CR1	MEL200	5.5	12	13	15	24	30	0	2	0	118
8	F	60	NHL	CR2	BEAM	6.2	12	15	na	na	na	3	11	4	19 dead
9	M	28	HL	CR3	CBV	6.5	10	11	13	15	17	3	1	2	75
10	M	45	MM	PR1	MEL200	6.7	10	11	12	15	na	0	1	0	50
11	M	30	HL	CR2	BEAM	5.1	9	10	15	18	20	2	1	1	46
12	F	20	HL	CR2	BEAM	5.3	10	11	11	13	15	8	0	2	45
13	F	31	HL	PR2	BEAM	12.0	8	9	10	13	19	9	0	1	39
14	M	48	MM	CR1	MEL200	5.0	10	11	12	12	18	4	3	1	18
15	M	28	HL	CR2	BEAM	20.0	10	10	12	12	14	1	2	0	15
	median	40				5.5	10	11	12	15.5	20	2	1	1	75
	range	20-60				4.6 -20.0	8-12	9-15	10-17	12-44	14-67	0-11	0-11	0-6	15-223

Pt. = patient; HSCT=hematopoietic stem cell transplantation; MM = multiple myeloma; NHL = non-Hodgkin lymphoma; HL = Hodgkin lymphoma; MEL = melphalan; BEAM = BCNU, etoposide, ara-C, melphalan; CBV = cyclophosphamide, BCNU, etoposide; PMN = polymorphonuclear cells; PLT transf = platelet transfusions; RBC transf = red blood cells transfusions; na = not achieved

We decided to dedicate our efforts to the development of HSCT at the HCH of Sulaymaniyah mainly for two reasons. First, HCH is today the main center in the Kurdish territory treating hematologic malignancies and congenital disorders as thalassemia major, the latter occurring at high frequency in Kurdistan. Second, at the time of our first visit the HCH counted already with most of the facilities necessary for an HSCT program, nevertheless an external support would be needed.

Specifically, in the project we developed at the HCH, the capacity-building methodology addressed the implementation of a sustainable HSCT program through the collaboration with experts in the field of adult hematology, pediatric hemato-oncology, transfusion medicine, apheresis, infectious diseases, nursing, cell manipulation, molecular biology and biophysics coming from different Italian institutions. Almost all these experts had a specific and long-lasting experience in the field of HSCT, and were selected not only on the basis of their competence, but also of their previous experience of cooperation with developing countries. All of them were volunteers, while the non-governmental organization ICU provided funds administration and reporting.

It is a common belief that among the main obstacles in the implementation of technically sophisticated procedures, as it is the case for HSCT, the most important are the frequent lack of a priority scale, the absence of teamwork as well as of appropriate methodology for problem-solving, decision-sharing and quality management. A tendency not to establish a transparent and effective responsibility tree is another factor. All these issues are more prominent in developing countries, where also procurement of resources and consequently of instrumentation and reagents is often critical.

Since the beginning our efforts were dedicated to training. Different techniques were used, not only the traditional lectures and seminars, but principally the coaching method. Written protocols and procedures were developed, and the method of shared decisions was adopted to solve the clinical and laboratory problems. This is a key function not only for the start-up but also for quality control and improvement.

On-site training and coaching represent an innovative method to establish a sustainable activity in developing countries, as alternative to a more traditional one, where local professionals to be trained are brought to the specialized center(s) with higher expenditure and less predictable final results. At present, we have no evidence that on-site training has more efficacy compared with the traditional methodology, and what are the situations where it would be more appropriate. With all the current limitations for immigration policies, in the future more projects based on capacity building on-site will probably be developed, and more data will be available.

With the start-up of the autologous transplantation program in June 2016 the HCH progressively developed an autonomous capacity, and consolidated the technical skills not only in the fields of apheresis, cell manipulation and immunohematology, but also in the infection control.[16] In fact, by the end of 2016 among the 15 patients autografted, only one developed a life-threatening infectious complication, but was eventually rescued. Another patient died, due to sudden heart failure following initial engraftment, a complication likely to be in part linked to age and a borderline cardiac function. More severe criteria for admission were consequently setup. Overall, the preliminary results seem encouraging with prompt and stable hematologic recovery in all and few severe complications.

The allogeneic transplantation program for thalassemia at HCH, carries many advantages for the country: it reduces psychosocial and financial burden for families and allows significant saving for the government.[17] The estimated costs of performing locally HSCT are lower than in the countries where patients were previously referred; a systematic analysis of this costs will soon be performed. Moreover, the new skills acquired together with the continuation of cooperation are paramount for further implementing the activity and extending the transplantation accessibility to children with other disorders, as leukemias, bone marrow failures, immune-deficiencies and others.

Here only the initial results of the HSCT activity at the HCH are reported. We are aware that, after start-up, transplantation activity needs resources and organization over the medium and long term to ensure full autonomy of the Center. To that purpose we also introduced the center to the international context registering it as full member in the EBMT, and promoted the search for scientific grants in order to allow medical doctors and other professionals to visit other

centers in Europe and the US. In addition, a new project on pediatric hematology was submitted to the AICS and recently funded. This new project, managed by the NGO AVSI, is aimed at improving biological and clinical aspects of childhood leukemia management at the HCH, but also to strengthen the transplantation program, especially in the allogeneic field.

Conclusions. Thanks to the cooperation initiative we described, the HCH is the only center performing also allogeneic HSCT in the Iraqi Kurdistan Region, and in the whole Iraq. We conclude that international cooperation may be of great value also in the field of high-technology medicine, and may contribute to improve the capabilities even of centers in critical contexts, representing a valuable instrument also in fostering country-to-country scientific exchanges.

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