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E-Art: An Assisted Reproductive Technology Information System for Infertility Management in Low Resource Settings

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ABSTRACT

Research Question: How an electronic medical record E-ART was designed and implemented for the monitoring and management of infertile couples in Dakar, Senegal?

Design: The study was carried out in the scenario of a public hospital of a reference university maternity hospital in Senegal, a private clinic, anda lab practice. The compilation of data for the automatic calculation of performance indicators and its transcription to a standard in electronic form was carried out by specialists in Gynecology-Obstetrics, Biologists, and Computer Scientists.

Results: E-ART software is structured around several hierarchical tables allowing users to register and store all relevant patients' information. E-ART structures the patient's data to provide a clear overview of their medical history and users' activity performance. E-ART makes medical users' life so much easier. Users can generate and send letters, prescriptions quickly and efficiently using the customized templates which they can modify or create. In addition to these capabilities, all of the features expected in an Assisted Reproductive technology EHR are handled by E-ART, such as ovarian stimulation monitoring, blood test measurements, egg retrieval, embryo culture, embryo transfer and so much more. E-ART makes it possible to manage all stages from ovarian stimulation to embryo transfer. The E-ART software also allows to generating reports and statistics according to customized templates and those of ANARA.

Conclusion: The computerization of medical records has become a necessity today. An area as sensitive as the management of infertility and ART techniques cannot escape to it. Crossing the line to Electronic medical records could help assess practices in order to improve them.

Keywords: Infertility; Medically assisted procreation; E-AMP; Electronic Medical File

INTRODUCTION

Infertility, a worrying scourge in our country, is taken care of in a very heterogeneous way. Investigations are often poorly prioritized, treatment held empirical. Assisted reproductive techniques are rarely used in the public sector, which justifies why more than 90% of the population does not have access to them. Until recently, only one private laboratory for Assisted Reproductive Technology (ART) existed in our country. A second private laboratory was created recently, bringing the number of laboratories to 2 but all in the private sector.

The management of infertility, in particular the ART techniques, has seen renewed interest from young Senegalese practitioners, many of whom have been trained in developed countries such as France. However, the management of infertility must be multidisciplinary, therefore harmonized as a team. The lack of coordination in the management of infertility and other

reproductive health issues makes the practices very disparate leading to real diagnostic and therapeutic wanderings.

Recent work within our team has shown that practitioners were not equipped to deal with infertility in its most basic aspect that is investigation [1]. An as yet unpublished evaluation on the management of infertility has highlighted the following path: patients are seen in medical offices maintained by obstetricians until they join the laboratory for intra-uterine insemination or embryo transfer. In several offices, no medical records were kept by physicians.

On this background, we decided to set up an electronic medical record to harmonize care, monitor patients and have brightness and transparency on the activity. This objective is consistent with this idea from Belaisch-Allart: "Wouldn't transparency be a factor in emulating towards better doing? " [2].

METHODS

The study was carried out in a public hospital, a university maternity hospital in Senegal and in a private clinic. We carried out an initial assessment to several medical offices and labs. A database management system was only found in 2 private clinics and one in the public sector. However, Electronic medical recording systems found in theses settings were not suitable for the management of infertility. Neither laboratory had ART software.

Computers were in place in most of the settings but used for the Internet access. As the settings did not yet have an integrated electronic recording system, the information was stored in unstructured and semi-structured files.

Subsequently to this assessment, a predefined set of data was considered to be vital to automatically generate the selected indicators. Among these: the profile of the two spouses, the medical history data, the infertility data and treatment process. We then moved to develop a specific software for collecting, entering, storing and analyzing data. Finally, a prototype of the EMR designed has been tested in a University hospital and in a private clinic.

RESULTS

Description of E-ART

E-ART was designed using Filemaker Pro Advanced software version 16, Macintosh. E-ART is made of tables that are in relationship via foreign keys to the core table. It provides a solid foundation for the users so that they can interact with the data stored in the software. The interface mainly evolves around layouts and layout objects. E-ART interface was designed using web design tools and takes into account users' recommendations (physicians). The logic of the solution automates the tasks of users in order to increase their productivity. Calculations and scripts are the two main tools FileMaker Pro provides to automate the logic of the solution.

Calculations provide access to complex and calculated data and require minimal interaction with users. Scripts allow users to perform tasks quickly and efficiently by automating parts of the

process or by guiding users through the process. Scripts and calculations improve data integrity by standardizing processes. E-ART via FileMaker Pro provides tools for generating step-by-step reports, including attractive graphs to efficiently analyze and summarize data which can be sent by email, saved to Excel/PDF or printed out to share with colleagues. To do this, E-ART combines data, an interface and the logic of a solution. One or more users may be accessing E-ART using FileMaker's deployment capabilities. E-ART can be used as a local storage on a workstation or hosted on FileMaker Server on a local or remote server (hosting).

Tables and layouts

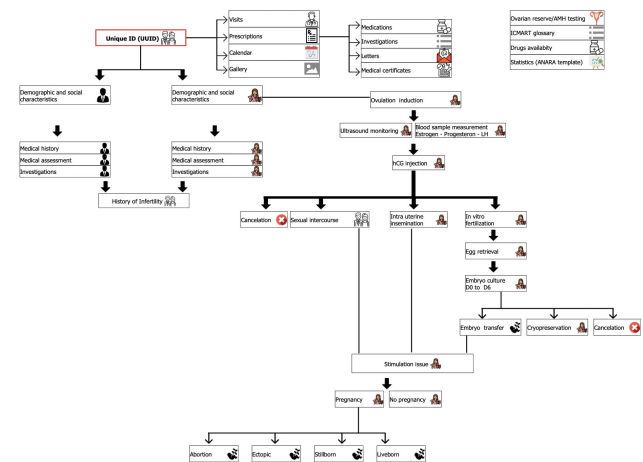E-ART structure is displayed in Figure 1.

Figure 1: Structure of E-ART

Core table, general information

Regarding the organization, we designed the core of the database to be the patient's General information table providing a primary key which populates the foreign keys of the related tables. Demographic characteristics of both spouses are stored within this table. The primary key is a 128-bit Universally Unique IDentifier (UUID) automatically generated by the software upon the creation of a new record. The UUID is unique. Patient's name, date of birth, date of admission, addresses, telephone numbers and email addresses, occupation, marital status are kept in this table. The same information is entered for the spouse.

Medical history, visits tables, history and Infertility assessment tables

Medical history from both spouses is reported as well as visits, in separate related tables. The template of clinical examination and the investigations were inspired by two papers published by the Practice Committee of the American Society for Reproductive Medicine [3,4]. Reporting the causes of infertility is performed via pop-up menus including causes of infertility for both men and women.

Prescribing investigations, certificates, letters and prescriptions

The "Prescribing" module is made up of 4 tables: medical prescriptions, investigations, writing letters and medical certificates.

To help physicians in an easy way to perform their job and save writing time, E-ART provides them with several standard prescriptions for ovarian stimulation that can be modified if necessary. Others can be created and stored. Physicians can easily prescribe investigations from check-boxes or drop-drown menus. Furthermore, button bars are provided to automate prescriptions according to guidelines in infertility investigation. Prescriptions can also be sent to patients by email. Medical certificates and letters follow the same process.

Gallery table

Any media file (photo, audio, video) can be stored in the Gallery table and easily displayed, printed or shared with other physicians or patients.

Treatment process tables

Ovarian stimulation: A special table allows to register stimulation starting date, stimulation rank order, stimulation medications (Clomiphen citrate, FSH, LH, hMG, letrozole, hCG) as well as medications to prevent premature ovulation such as Gonadotrophin releasing hormone (GnRH) agonists and GnRH antagonists.

Monitoring of ovarian stimulation: The ovaries are assessed during treatment with vaginal ultrasound examinations to monitor the development of ovarian follicles whereas blood samples (estrogen, LH and progesterone) are measured to evaluate the response to ovarian stimulation medications. Ultrasound findings (number of follicles, sizes, endometrium measurement) as well as blood sample measurements are recorded in separated tables allowing a quick overview of the stimulation.

At the end of the ovarian stimulation cycle, depending on the ART technique, users can select either IUI, classic *In Vitro* Fertilization/Intracytoplasmic sperm injection, sexual intercourse or cancelation to register items specific to the technique.

Transvaginal ovum retrieval procedure is recorded in a specific related table. Embryo culture conditions are also detailed as well as the results of the observation. At D1 (D for day) and D2, the assessment of zygotes and embryos is informed using the classification of BLEFCO [5]. Beyond that stage, Gardner et al.'s classification is the one used [5].

Embryo culture is followed either by embryo transfer, cryopreservation or cancelation. Each of these events is registered. In the event of a pregnancy, E-ART provides a link to the original reproductive treatment and allows a complete monitoring of the patient's pregnancy, specific tests according to the trimester, history of all follow-up appointments, as well as previous pregnancies.

Tools tables

Appointments: Appointments are added into the database from any point and by any permitted user (desks, physicians). These can be modified or cancelled. Outputs sorted by activity can be displayed, printed out or shared by mail in PDF format. This allows better planning of ultrasound monitoring, egg retrievals and embryo transfers.

Drugstore table: In Senegal as in other low resource settings, ART medications are not all or all the time available. To help physicians in their prescriptions, we have set up table which encloses availability of ART drugs and their prices in the 4 biggest pharmacies in Dakar (Figure 2). This table is updated on a regular basis.

ANTAGONISTE	CETROTIDE	0,25mg	poudre+ solvant +seringue	SC	€ 47,03	49 209 FCFA	55 186 FCFA	48 250 FCFA	53 625 FCFA
ANTAGONISTE	CETROTIDE	3mg		SC	€ 224,34				
CLOMIFENE	CLOMID	50 mg		Orale	€ 3,47	3 613 FCFA		3 613 FCFA	
CLOMIFENE	CLOMID	50 mg		Orale	€ 3,47	7 936 FCFA	7 935 FCFA	7 895 FCFA	7 936 FCFA
AGONISTE	DECAPEPTYL	0,1 mg		SC	€ 39,6	40 439 FCFA	87 006 FCFA	39 236 FCFA	39 236 FCFA
AGONISTE	DECAPEPTYL LP	3 mg		IM	€ 122,95	99 755 FCFA		99 715 FCFA	106 005 FCFA
AGONISTE	DECAPEPTYL LP	11,25 mg		IM	€ 347,43				
AGONISTE	DECAPEPTYL LP	22,5 mg		IM	€ 665,11				
GONADOTROPHINE	ELONVA	100 UI		SC	€ 512,36				
GONADOTROPHINE	ELONVA	150 UI		SC	€ 512,36				
GONADOTROPHINE	FOSTIMON	75UI/ml		SC	€ 18,44				
GONADOTROPHINE	FOSTIMON	75UI/ml		SC	€ 83,59	98 600 FCFA	88 636 FCFA	98 603 FCFA	88 639 FCFA
GONADOTROPHINE	FOSTIMON	150UI/ml		SC	€ 34,72				
GONADOTROPHINE	FOSTIMON	150UI/ml		SC	€ 159,11				
GONADOTROPHINE	FOSTIMON	225UI/ml		SC	€ 48,2				
GONADOTROPHINE	FOSTIMON	225UI/ml		SC	€ 225,2				
GONADOTROPHINE	FOSTIMON	300 UI/ml		SC	€ 62,91				
GONADOTROPHINE	FOSTIMON	300 UI/ml		SC	€ 298,02				

Figure 2: E- ART drugs and their prices in 4 bigger pharmacies in Dakar, Senegal Prices are displayed in euros (on the company website) and CFA, the local currency

Glossary table: To bring clarity and offer a better understanding and enhance user experience, a glossary of the International Committee for Monitoring Assisted Reproductive Technology (ICMART) and the World Health Organization (WHO) revised glossary of ART terminology [6] is available in the databases.

Ovarian reserve/AMH test

Also included in the software is a calculator of ovarian reserve according to Younis et al. [7] as well as AMH reference tables allowing to interpret results with levels of other women of the same age.

Requests and dynamic reports

One of the main purposes of E-ART is to provide activity reports via requests. These allow physicians, board and health authorities to instantly access to relevant epidemiological data. Results can be displayed to match different templates such as that of African Network and Registry for Assisted Reproductive Technology [8]. To go further, E-ART offers a real-time dashboard of the activity according to the chosen period. Each category offers the possibility of going much further in statistical analysis.

DISCUSSION

Several medical data management systems have been developed and are commercially available [9-16]. E-ART is a client-server electronic medical record (EMR) system created using FileMaker. FileMaker was chosen because it was the only application with the necessary set of tools: a client/server application that works in a wireless LAN, on Windows or Mac OS laptops, on iOS mobile devices (iPad and iPhone) and a physician who had expertise in FileMaker. FileMaker is a great and cost-effective tool for making databases. The local network provides access to the database system from each workstation. The system itself provides quick access to all patients and processing of information, plan screenshots and medical documentation. Additionally, the system allows a quick request on the entire patient's medical information. All data is at hand during the follow-up examination and is accessible at any time.

Prospective data collection provides complete, accurate and valid data. The clearly organized and structured data entry and the continuous control scripts ensure the quality of the data collection. Complex query scripts make it easy to retrieve large datasets. These datasets are processed for predefined statistical analyzes. All data can be saved as Excel or SPSS (Statistical Package for Social Science) sheets for further statistical analysis.

The database serves as a broad information base for scientific questions, integrating all relevant medical and technical information into one system. Several software packages allow working with a single database in centers located in different geographic locations. Each center can count on its own patients and users or share them with other users. At our level, we operate locally due to the instability of the Internet in our country. The short-term goal is to switch to online use.

The complexity of monitoring ovarian stimulation and adjusting drug doses, planning egg retrievals and embryo transfers requires a high organization. Certain information which can have a significant influence on the care of the patient can be omitted from the paper medical record. Some illegible script may be misinterpreted. To manage these tasks without an electronic tool seems difficult or risky. E-ART adds organization and security. This is an innovative step in data management in the realm of reproductive health in Africa. This improvement has a positive impact on patient safety

Our system is designed to provide various reports including those that suit to the African

Network and Registry for Assisted Reproductive Technology (ANARA). ANARA brings together assisted reproductive technology centres within and between African countries; and collects and disseminates scientific data on the availability and practice of assisted reproductive technology on the continent [8]. Senegal is involved in ANARA network; thus, the local ANARA representative provides ANARA with data extracted from E-ART in no time.

Besides the development and implementation of the software, the adoption of data management (data entry) in daily workflows is crucial. Depending on the amount of data and the complexity of the database system, a dedicated data manager or administrator is required [17]. If no additional staff can be allocated for this purpose, at least one coordinator is needed to organize the data entry and adapt the workflow to the existing workforce. This task is often assigned to the physician who created and implemented the database. A key aspect of the sustainability of E-ART is to ensure that there is a local technical team capable of resolving any problems that arise and performing routine maintenance.

The use of this tool and the definite advantages as well as the issues already identified constitute as many elements which in the long term, can encourage the Ministry of Health of Senegal to set up a Biomedicine agency.

CONCLUSION

The computerization of medical records has become a necessity today. An area as sensitive as the management of infertility and ART cannot escape it. The adoption of ART could help assess practices in order to improve them. To meet standards and compare our results to those of other countries, the adoption of ICMART terms is imperative.

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