ORIGINAL ARTICLE: FERTILITY PRESERVATION

Sperm cryopreservation in adolescents and young adults with cancer: results of the French national sperm banking network (CECOS)

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Objective: To determine the feasibility of fertility preservation in adolescent males with cancer.
Design: Large multicenter retrospective study of male patients ≤20 years from 23 centers of a national network of sperm banks over a 34-year period.
Setting: Sperm banks.
Patient(s): A total of 4,345 boys and young men aged 11 to 20 years.
Intervention(s): Age, cancer diagnosis, feasibility of sperm banking, and sperm parameters.
Main Outcome Measure(s): Description of patients, and success of their fertility preservation.
Result(s): We observed a mean yearly increase in referred patients of 9.5% (95% confidence interval, 9.1%–9.8%) between 1973 and 2007. Over the study period, the percentage of younger cancer patients who banked their sperm increased, especially in the 11–14 year age group, rising from 1% in 1986 to 9% in 2006. We found that 4,314 patients attempted to produce a semen sample, 4,004 succeeded, and sperm was banked for 3,616. The mean total sperm count was 61.75×10^6 for the 11–14 year age group, and 138.81×10^6 for the 18–20 year age group. It was noteworthy that intercenter variations in practices involving young patients seeking to preserve their fertility before cancer therapy were observed within this national network.
Conclusion(s): Our results emphasize the need for decisive changes in public health policy to facilitate the access to reproductive health-care for young cancer patients. (Fertil Steril® 2014;■:■–■. ©2014 by American Society for Reproductive Medicine.)
Key Words: Adolescents, age, cancer, fertility preservation, sperm cryopreservation

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Over the past quarter century, cancer incidence in adolescents and young adults (AYA) has been rising, while at the same time major advances in therapeutic management have led to improved prognoses (1). In 1994, it was estimated that in Britain over 10,000 adults were long-term survivors of childhood cancer (2). Similarly, several countries have reported improvements in survival rates in AYA diagnosed with cancer (3–8).

In addition to overcoming their disease, an important issue for these AYA men is how the malignant disease and its treatment (surgery, radiation, and/or chemotherapy) will affect, transiently or permanently, their future fertility (9). To meet this challenge, banking samples of semen before treatment seems the most reasonable approach. Although sperm banking for fertility preservation is a relatively easy and effective procedure in adults, such procedures and their success remain more problematic in young male populations (10–12). Numerous investigators working in this field have highlighted several key points and difficulties in AYA sperm collection, such as ensuring adequate information delivery by medical teams, ascertaining the young person's views on future parenthood, obtaining essential cooperation from AYA men confronted with a very stressful experience, and using various options to enable sperm collection (masturbation, vibratory stimulation, electroejaculation) (13–18).

In France, an original and unique public network of sperm banks was created in 1973: the Centres d'Etude et de Conservation des Oeufs et du Sperme humains (CECOS). The 23 regional sperm banks affiliated with the CECOS network now offer service to the whole country. Our retrospective study, covering a period of 34 years (1973–2007), reports on the practices and results among AYA men with cancer who were referred for sperm banking to the French regional sperm banks affiliated with the CECOS network.

MATERIALS AND METHODS

Patient Population

In the 23 French regional sperm banks affiliated to the CECOS network (Amiens, Besançon, Bordeaux, Caen, Clermont-Ferrand, Dijon, Grenoble, Lille, Lyon, Marseille, Mulhouse, Nancy, Nantes, Nice, Paris-Cochin, Paris-Necker, Paris-Tenon, Reims, Rennes, Rouen, Strasbourg, Toulouse, and Tours), we performed a retrospective study by collecting information on male cancer patients aged 20 years and younger who were referred for sperm cryopreservation between July 1973 and December 2007. The study was approved by the Ethic Committee from University Hospital of Toulouse.

In accordance with the rules and procedures established by the CECOS network, the management of patients was similar in all 23 sperm banks. Usually, patients come to the CECOS after cancer diagnosis and before the start of treatment. In each participating sperm bank, the procedure was as follows: a consultation with a trained practitioner was provided to explain the adverse effects of cancer treatment on spermatogenesis and the different methods for collecting semen (masturbation, penile vibratory stimulation, postmasturbation urine sample, or testicular sperm extraction). The aim (preservation of future fertility) and timing of cryopreservation (before cancer treatment) were explained to the AYA and to their parents. To respect an adolescent's privacy when he is alone for masturbation, he is seen separately from his parents in a one-to-one consultation. During the consultation, we assess whether masturbation is feasible and take into account the adolescent's psychological readiness. Before sperm collection and cryopreservation, we explain simply and openly what is required for sperm collection and exactly how to use the semen receptacle. After the last sperm collection, we explain sperm parameters and straw quality. It should be noted that management is not

standardized; rather, it is flexible and adapted to the different situations that arise.

Semen analysis was performed according to the World Health Organization (WHO) recommendations, after liquefaction for 20 minutes at 37°C. The samples were frozen after dilution into a cryoprotectant medium taking into account spermatozoa number and mobility. Cancer diagnoses were classified according to type, as lymphomas, germ-cell tumors, leukemia, malignant bone tumors, soft-tissue sarcomas, carcinomas, and central nervous system tumors, with other cancers grouped together.

Statistical Analysis

In addition to the patient's age at study inclusion and cancer type, the various methods used for sperm collection, the percentage of semen samples and samples frozen, and semen parameter results were recorded in each of the 23 sperm banks. Data were anonymized and then centralized for processing and statistical analysis in the Toulouse referent center.

A correlation test was used for quantitative variables. A Wilcoxon test was used to test the association between age group and semen parameters (volume, sperm concentration, total sperm count, motility, and vitality). We analyzed these parameters for the first sperm sample obtained by masturbation alone. The average annual percentage change of sperm preservation was calculated using a Poisson model. Correlations between the ability to provide a semen sample, sperm banking, age (three age groups: 11–14, 15–17, and 18–20 year old), and cancer type were sought using a generalized linear model.

To compare during the same period the global number of cancer patients recorded and the number of these patients who banked sperm, we used data on cancer types and patient age from French cancer registries and the French Ministry of Health (19). We restricted the analysis to hematologic cancer and germ-cell tumors during the period 1975–2005 for two age groups (10–14 years and 15–19 years), which were identified from the data available in the French cancer registries. We thus determined the proportion of young patients with cancer who were referred to the regional sperm bank network (CECOS). Analyses were performed using SAS software (version 9.3; SAS Institute), and the significance level was defined as 5%.

RESULTS

Population

From July 1, 1973, through December 31, 2007, 4,345 AYA males with cancer aged 11 to 20 years were referred to the 23 regional CECOS banks for fertility preservation.

Types of Cancer and Trends

Among the 4,345 patients, the most frequent types of cancer were lymphoma cancers (1,721), germ-cell tumors (1,030) and leukemia (651) (Supplemental Fig. 1, available online). In rare cases, patients were referred after treatment had been started: chemotherapy in 289 patients (7%) and radiotherapy in 30 patients (1%).

In our whole study population, we observed a mean yearly increase in patients of 9.5% (95% CI 9.1%–9.8%) between 1973 and 2007. Statistically significant mean yearly increases were observed for all types of cancer, from 7.0% for the "other cancers" group to 10.7% for the group of central nervous system tumors. The increase was 7.4% (95% confidence interval [CI], 6.9%–8.1%) for lymphomas, 7.6% (95% CI, 6.9%–8.5%) for germ-cell tumors, and 10.3% (95% CI, 8.9%–11.6%) for leukemia (Fig. 1A). No differences in time trends of increased incidence were observed among the various types of cancer.

Age

The mean age at admission was 18 ± 2 years (median 18 years). More than half the patients were aged 18 to 20 years, 39% were aged 15 to 17 years, and 5% were younger than 15 years (the youngest patient was aged 11 years). The percentage of younger cancer patients increased steadily over the study period, in particular those aged 11–14 years increased from 1% in 1986 to 3% in 1996 and 9% in 2006 (see Fig. 1B). Whereas few patients younger than 15 years were referred during the 1970s and 1980s, a gradual increase was observed in the late 1990s and a marked increase in the early 2000s. Between 2000 and 2007, patients aged younger than 15 accounted for 8% of referrals (173 patients) compared with only 3% (32 patients) between 1992 and 1999. According to age groups, the yearly increase was 16.3% (95% CI, 13.4%–19.4%) for ages 11–14 years, 10.5% (95% CI, 9.9%–11.3%) for ages 15–17 years, and 7.9% (95% CI, 7.4–8.4%) for ages 18–20 years. According to type of cancer, the mean ages were 18 ± 2 years for lymphomas, 19 ± 2 for germ-cell tumors, and 18 ± 2 for leukemia.

Semen Collection and Semen Parameters

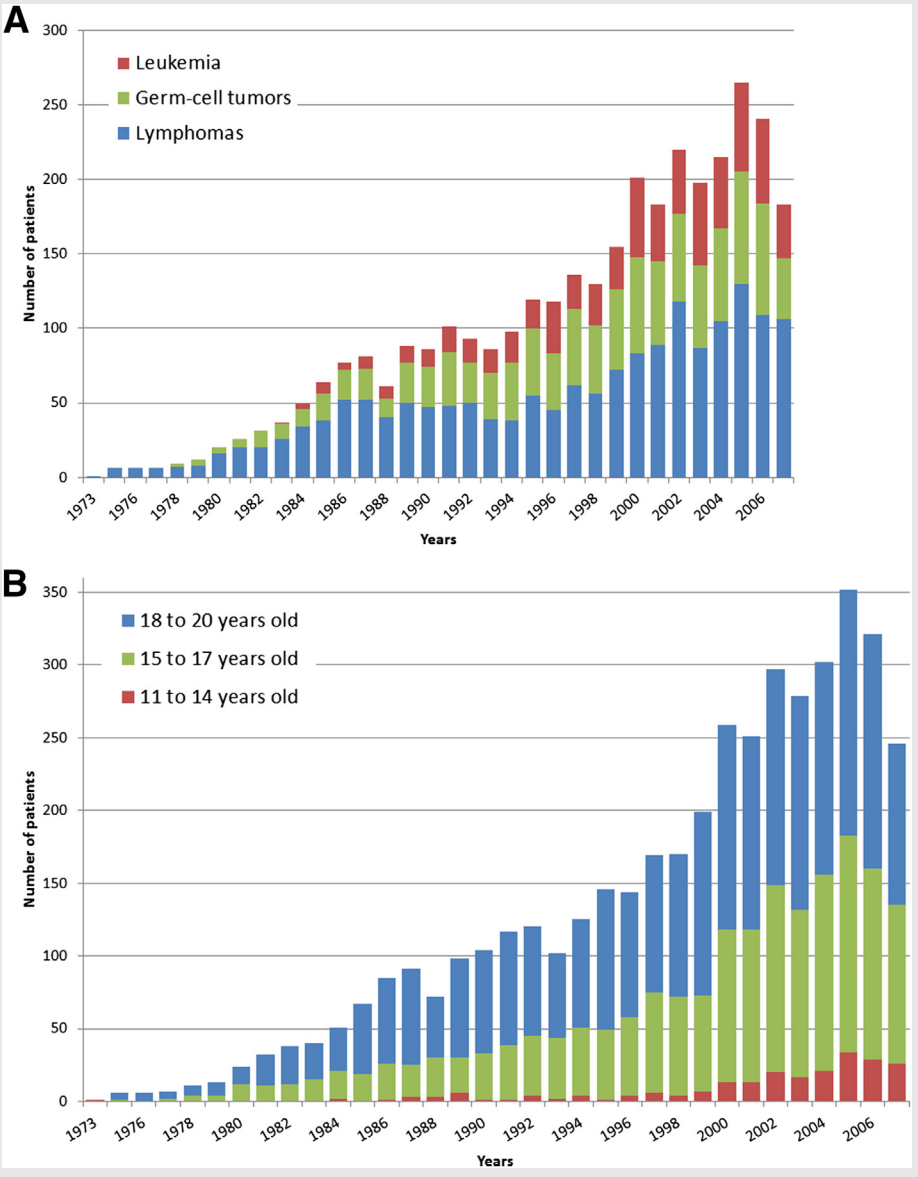
Of the 4,345 patients seen in consultation and who were given information on methods of sperm collection and on sperm freezing, 4,314 (99%) attempted to provide at least one sperm sample by masturbation, and 31 patients did not make an attempt (refusal); 310 failed to provide a sperm sample by masturbation, and 4,004 (93%) succeeded.

In the 4,004 patients who provided sperm by masturbation, one or several samples were frozen in 3,616 (83%). For the remaining 388 patients, freezing was not possible due to very small semen volume, low motility, and/or insufficient number or absence of spermatozoa.

In a few of the 310 patients who failed to provide sperm by masturbation, other collection techniques were used: penile vibratory stimulation in 3 patients with no sperm freezing, endorectal ejaculation in 2 patients with sperm freezing in 1, search for spermatozoa in urine for 2 patients with no sperm freezing, and testicular biopsy and sperm extraction for 6 patients with freezing for 5 of these (Fig. 2).

In our series of 4,345 patients, sperm collection by masturbation was found to be feasible from the age of 12 years. Feasibility increased significantly with age: 81% of patients succeeded in the 11–14-year age group, 91% in

FIGURE 1



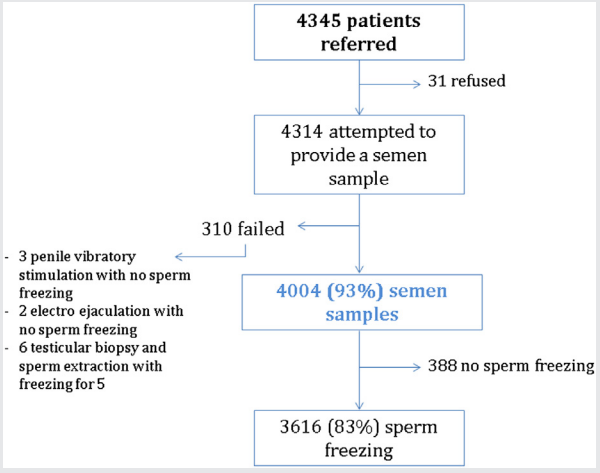
Change over time in the number of the 4,345 patients referred for sperm cryopreservation according to (**A**) three most frequent types of cancer: lymphomas, germ-cell tumors, and leukemia, (**B**) age group (11–14, 15–17, 18–20 year old).

Daudin. Sperm banking in adolescent cancer. Fertil Steril 2014.

the 15–17-year group, and 95% in the 18–20-year group ($P<.001$). Of the 4,004 patients whose sperm was obtained by masturbation, 19% provided one sample, 46% two samples, and 35% three and more (with no difference according to age).

Table 1 shows semen parameters for the first ejaculate for the whole study population, and according to age group and type of cancer. A statistically significant difference was found for all parameters according to age. The mean total sperm count increased from 61.75×10^6 spermatozoa for the 11–14-year age group to 138.81×10^6 for the 18–20-year age group. Mean motility and vitality were 33% and 52%, respectively, for the youngest age group and 37% and 61% for the 15–17-year age group, reaching 39% and 64% for the 18–20-year age group. There was a statistically significant difference in the total sperm count according to age and according to type of cancer, doubling between the 11–14 and 15–17 year age groups for lymphomas, leukemia, and malignant bone tumors and decreasing for germ-cell tumors (from 80–49 million spermatozoa). Motility increased with age only for lymphomas (from 33 ± 20 at ages 11–14 years to 40 ± 20 at ages 18–20 years) and germ-cell tumors (from 29 ± 25 at ages 11–14 years to 40 ± 21 at ages 18–20 years).

FIGURE 2



Flowchart of patients' success in sperm sample production.

Daudin. Sperm banking in adolescent cancer. Fertil Steril 2014.

Proportion of Cryopreservation in Relation to Cancer Incidence

Figure 3A and 3B present the number of patients having cryopreservation as a percentage of the number of cancer cases, using data from the French cancer registries and the French Ministry of Health (19) according to age (10–14 years and 15–19 years) for hematologic tumors (lymphomas and leukemia) and for germ-cell tumors. It shows that for the youngest patients (under 15 year old) the practice of cryopreservation started only at the end of the 1980s.

DISCUSSION

To the best of our knowledge, our study is the largest retrospective study (n = 4,345) to be performed of sperm cryopreservation in AYA males with cancer. It covered a period of 34 years and included AYA with cancer who were offered fertility preservation through the 23 French regional sperm banks affiliated to the CECOS network. Whereas fertility preservation is relatively easy in adults (with very high success rates of 97%–98.6%) (20, 21), this practice appears more complicated in adolescents, so it is generally not routinely proposed. A key result of our study is a demonstration on a nationwide scale of the acceptability, feasibility, and success of fertility preservation in AYA patients. Of the 4,345 patients enrolled, 93% succeeded in providing a sperm sample by masturbation, and the sperm of 3,616 (83%) was frozen. A similar study was performed in the United Kingdom in 180 patients aged 13.2 to 17.9 years who were referred from 1995 to 2009 for cryopreservation in assisted conception units. Of these young patients, 66% successfully banked sperm, 10% were unable to provide a sample, and 13% had azoospermia (22). Our results are also in accordance with those obtained by several investigators in much smaller patient series: 84% of 25 patients for Müller et al. (10), 83.7% of 80 patients for van Casteren et al. (23), and 86.1% of 238 adolescents for Bahadur et al. (24).

In a few small series, sperm preservation has been reported in patients aged 12. In our study, the youngest patient who successfully provided a semen sample was 12.4 year old, which is comparable to the youngest ages observed in other studies (24–26).

In our series based on a large number of young patients, the success of sperm preservation statistically significantly increased with age, from 81% success in the 11–14 age group to 95% in the 18–20 age group. In the literature, sperm preservation rates have generally been given for the whole population and not according to age groups, with reported global rates ranging from 60% to 93% (10, 14, 23, 25, 27–29). Only van Casteren et al. (23) examined the relation of sperm preservation to age; they did not demonstrate a statistically significant relationship, but their series was small.

If sperm cannot be collected by masturbation, other techniques may be used, as was done in a very small number of our patients. Assistance by penile vibratory stimulation, electroejaculation, or testicular biopsy have been proposed only since the year 2000 (30). Hagenäs et al. (25) performed electroejaculation in 11 patients, and sperm sampling was successful and cryopreservation possible in 5 of these patients. Although the choice of such techniques in AYA men is still a matter of debate, the statistically significant percentage of young patients unable to provide samples through masturbation (310 of 4,314 in our series) is a strong argument in favor of sensitive, very open discussions with AYA men and their parents on these other available methods (description, advantages, side effects, etc.) so that they may be offered all technical possibilities to preserve their future fertility (12).

Another interesting finding in our study is the increase over time in sperm cryopreservation in patients aged under 15, who were 3.5 times more numerous after the year 2000 than before. The increased frequency of cancer in the young cannot be the only explanation for the markedly increased demand for fertility preservation. This increase in demand is probably multifactorial and may have several explanations: improved life expectancy owing to effective treatments, better information to patients about their sperm preservation options before cancer treatment, and also greater awareness among the different medical teams, including oncologists and reproductive medicine specialists. In France, it is now a legal requirement that all patients must be informed about fertility preservation before any gonadotoxic treatment is started. Technical progress in reproductive medicine also plays a part, particularly with the development of intracytoplasmic sperm injection (but only after 1992) which enables pregnancy in spite of a very low number of frozen sperm cells. Moreover, the increased demand for fertility preservation may also be related to the closer collaboration between cancer teams and sperm banking teams, in accordance with the recommendations of the cancer and reproductive medicine societies (31). Furthermore, the attention given to the topic in the public media (including interviews with parents) certainly also has played a key role in the trends observed in sperm cryopreservation.

Finally, the cost of cryopreservation and sperm conservation are also key determinants in the use of sperm banking,

TABLE 1

Semen characteristics in 4,004 patients according to age and type of cancer.

Semen characteristics	Age (y) 11–14	15–17	18–20	All
All				
Ejaculate volume (mL)[a]	1.17 ± 1.16	2.02 ± 1.45	2.67 ± 1.62	2.36 ± 1.59
Total sperm count (10^6)[a]	61.75 ± 145.05	106.70 ± 173.97	138.81 ± 256.40	123.66 ± 225.87
Sperm concentration (10^6/mL)[a]	42.43 ± 65.83	52.04 ± 70.52	49.36 ± 72.98	50.08 ± 71.81
Motility (%)[a]	33 ± 21	37 ± 21	39 ± 21	38 ± 21
Vitality (%)[a]	52 ± 24	61 ± 21	64 ± 20	62 ± 21
Lymphomas				
Ejaculate volume (mL)[a]	1.06 ± 0.90	1.98 ± 1.42	2.54 ± 1.58	2.25 ± 1.53
Total sperm count (10^6)[a]	58.82 ± 149.10	123.33 ± 195.02	159.38 ± 278.71	140.72 ± 245.38
Sperm concentration (10^6/mL)[a]	46.25 ± 79.23	57.79 ± 73.53	57.74 ± 78.25	57.25 ± 76.46
Motility (%)[a]	33 ± 20	39 ± 21	40 ± 20	39 ± 21
Vitality (%)[a]	57 ± 23	62 ± 21	65 ± 20	63 ± 21
Germ-cell tumors				
Ejaculate volume (mL)[a]	1.68 ± 1.35	2.31 ± 1.60	2.90 ± 1.68	2.72 ± 1.68
Total sperm count (10^6)[a]	80.49 ± 260.42	49.44 ± 100.25	86.81 ± 217.28	76.77 ± 194.67
Sperm concentration (10^6/mL)[a]	23.75 ± 50.93	21.96 ± 34.84	28.42 ± 55.96	26.66 ± 51.13
Motility (%)[a]	29 ± 25	36 ± 21	40 ± 21	39 ± 21
Vitality (%)	56 ± 26	63 ± 21	65 ± 19	64 ± 20
Leukemia				
Ejaculate volume (mL)[a]	1.20 ± 1.42	1.84 ± 1.31	2.56 ± 1.54	2.17 ± 1.49
Total sperm count (10^6)[a]	42.23 ± 72.79	111.45 ± 167.53	175.12 ± 296.42	140.51 ± 242.81
Sperm concentration (10^6/mL)	40.69 ± 61.01	64.67 ± 89.59	62.19 ± 82.54	62.09 ± 84.71
Motility (%)	33 ± 21	33 ± 20	34 ± 21	33 ± 21
Vitality (%)[a]	32 ± 22	57 ± 22	58 ± 23	56 ± 23
Malignant bone tumors				
Ejaculate volume (mL)[a]	0.99 ± 1.37	1.95 ± 1.35	2.74 ± 1.50	2.25 ± 1.51
Total sperm count (10^6)[a]	63.22 ± 117.57	124.73 ± 147.07	215.57 ± 286.93	165.25 ± 238.63
Sperm concentration (10^6/mL)	42.12 ± 41.93	60.16 ± 61	74.84 ± 80.89	66.32 ± 71.11
Motility (%)	32 ± 22	40 ± 21	41 ± 19	40 ± 21
Vitality (%)	55 ± 24	62 ± 17	64 ± 18	63 ± 18
Soft-tissue carcinomas				
Ejaculate volume (mL)	1.82 ± 1.37	2.38 ± 1.84	2.86 ± 2.03	2.61 ± 1.93
Total sperm count (10^6)	111.27 ± 113.14	128.35 ± 207.96	130.26 ± 166.28	128.28 ± 178.63
Sperm concentration (10^6/mL)	48.51 ± 38.44	52.21 ± 66.44	45.21 ± 49.15	47.99 ± 55.19
Motility (%)	39 ± 22	38 ± 20	37 ± 20	37 ± 20
Vitality (%)	57 ± 19	65 ± 17	71 ± 10	67 ± 14
Carcinomas				
Ejaculate volume (mL)	1.00	1.89 ± 1.06	2.59 ± 1.60	2.35 ± 1.47
Total sperm count (10^6)	78.00	107.40 ± 148.13	108.15 ± 146.00	107.59 ± 145.14
Sperm concentration (10^6/mL)	78.00	49.85 ± 55.82	36.91 ± 43.60	41.38 ± 47.78
Motility (%)	35	36 ± 22	36 ± 23	36 ± 22
Vitality (%)	63	59 ± 22	65 ± 22	63 ± 22
Central nervous system tumors				
Ejaculate volume (mL)	1.10 ± 0.23	1.91 ± 1.52	2.26 ± 1.51	2.03 ± 1.49
Total sperm count (10^6)	67.60 ± 81.69	127.31 ± 221.82	128.42 ± 147.57	124.50 ± 184.54
Sperm concentration (10^6/mL)	68.00 ± 81.98	59.35 ± 84.43	72.17 ± 112.95	65.67 ± 97.57
Motility (%)	42 ± 16	34 ± 25	32 ± 19	33 ± 22
Vitality (%)	35	56 ± 26	53 ± 23	54 ± 24
Other				
Ejaculate volume (mL)[a]	1.01 ± 1.34	2.13 ± 1.75	2.59 ± 1.38	2.32 ± 1.59
Total sperm count (10^6)	55.80 ± 111.60	78.31 ± 98.07	82.92 ± 97.69	79.77 ± 97.53
Sperm concentration (10^6/mL)	18.63 ± 37.18	43.42 ± 51.41	30.86 ± 29.34	36.33 ± 21.81
Motility (%)	23 ± 32	31 ± 22	37 ± 21	34 ± 22
Vitality (%)	73	51 ± 24	64 ± 21	59 ± 22

Note: Values are mean ± standard deviation.
[a] $P<.001$, difference between age groups.

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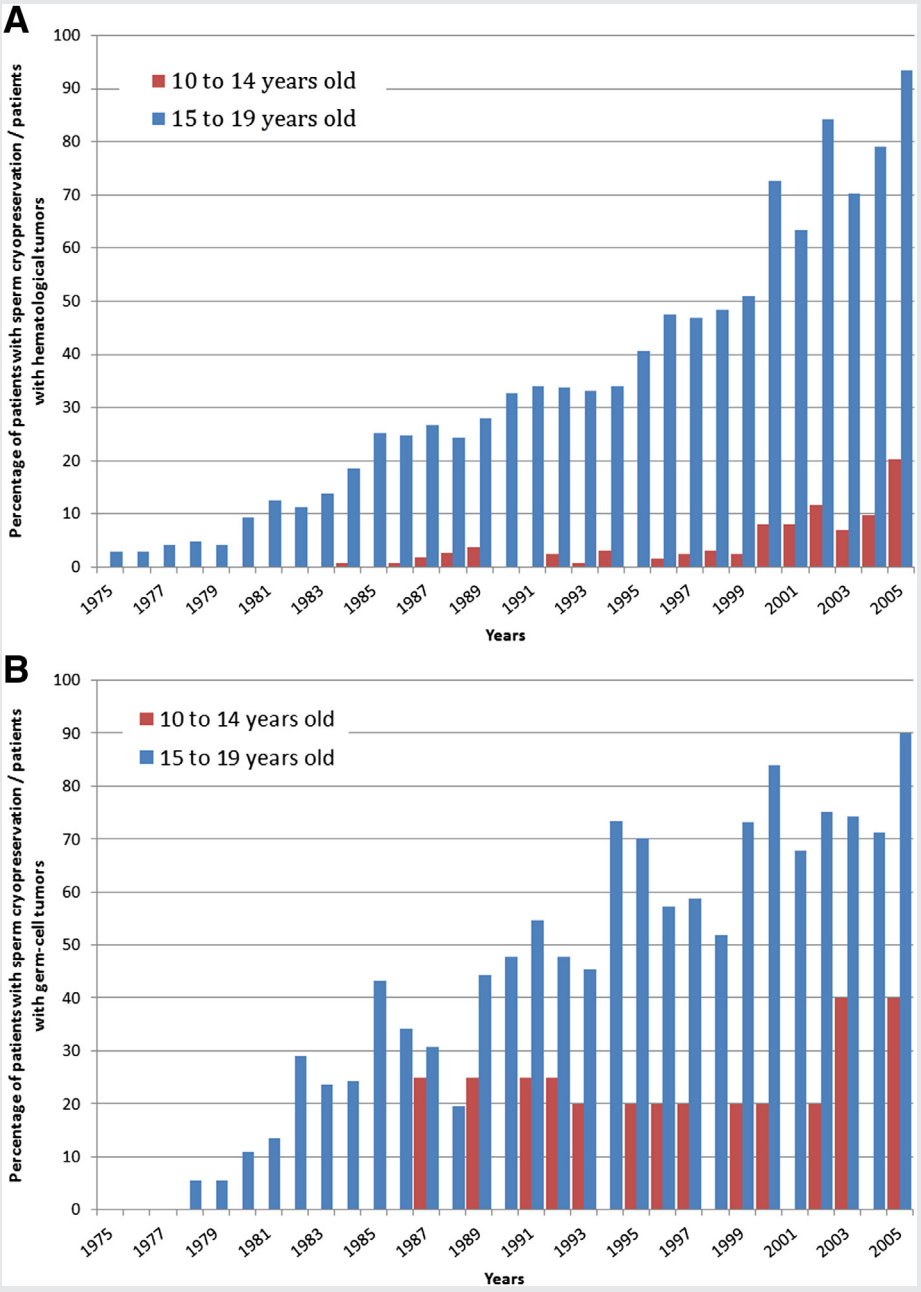
and these depend on national regulations. In countries where sperm banking costs are substantial, these may be an additional obstacle to sperm banking. However, in France, medical and laboratory costs are covered by national insurance and the direct cost to the patient of sperm cryoconservation is nil. This suggests that although cost may be a limitation to sperm banking, it is relatively minor compared with health-care attitudes, for example.

From a public health perspective, we noted variations in practices involving young patients seeking to preserve their fertility before cancer therapy, despite the regional CECOS sperm banks being organized on a national level with the

FIGURE 3



Number of patients having cryopreservation as a percentage of number of cancer cases. Data for cancer cases taken from Belot et al. (19) according to age: 10–14 years and 15–19 years for (**A**) hematologic (lymphomas + leukemia) tumors and (**B**) germ-cell tumors.

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same guidelines. Five centers did not provide fertility care to any patients younger than 15 years before the year 2000, and two others did not provide fertility care to this age group between 2000 and 2007. Such variations between centers have led to inequality in health care and have lessened the patients' chances of obtaining sperm cryopreservation. This seems unacceptable from an ethics viewpoint. It is interesting that a French study of a representative nationwide sample of survivors after an adult cancer diagnosis reported inappropriate or no information about fertility preservation before cancer treatment, but the young population concerned was not precisely identified (32).

Similar variations in the care offered were observed in postal surveys in various countries such as the United Kingdom, Australia, and New Zealand (13, 33). Underutilization of sperm cryopreservation was also observed in a Canadian center, where between 1995 and 2005 only 17.8% of male adolescents and young adults

used fertility preservation (34). The investigators found that patients appeared to be given inadequate information on the options available. In one North American center, a survey showed that only 28.1% of informed patients aged 13 years and older banked sperm (35). In a very comprehensive review of oncologists' attitudes, Schover et al. (36) identified numerous barriers that could discourage providers from discussing fertility risks and fertility preservation options with patients, and especially with AYA men. These included a lack of time, the urgency of treating the cancer, the providers' anxiety about discussing fertility and sexuality with AYA, and the opinion that the prognosis for the AYA was poor as well as cost and difficulty in finding convenient facilities.

To change such restrictive medical and paramedical attitudes toward fertility preservation and to encourage sperm banking, an interesting and successful participative method was implemented by the Seattle Children's Hospital in the United States. A continuous process improvement technique was introduced through specific workshops (including representatives of oncology, adolescent medicine, urology, nursing, social work, health education, parents, and patients) to standardize sperm cryopreservation processes. In these workshops, the following subjects were presented and discussed: reviews of existing literature on the topic, barriers discouraging providers from proposing sperm banking, presentation of patients' and parents' experiences, information on sperm banking facilities including out-of-pocket costs. The rates of sperm banking were compared before and after implementation of this method, with a eightfold increase (from 8% to 68%) in the proportion of AYA males who banked sperm in the 12-month period after implementation. As stated by the investigators, the continuous process improvement method could be an effective tool for the rapid design and implementation of a new standard working process for both patients and health-care providers (37).

Limitations

Our study of AYA referred for sperm preservation before starting cancer treatment was retrospective. No clinical examination of the patients was performed at the banking centers, and none was recorded in our data. Nevertheless, the cancer diagnoses of our population were similar to those of the general adolescent cancer population according to the International Classification of Childhood Cancer (ICCC) (38, 39).

Regarding age and sperm recovery in the youngest patients, we had no information on their Tanner stage, so we were unable to assess their true pubertal status. Thus, we used only chronologic age, as was done in several other studies (24–26). It is in fact difficult to know when the milestone of spermarche has been reached. Some studies consider that boys begin to ejaculate at around 13 years' bone age (40, 41).

Our study conducted in all 23 French regional sperm banks affiliated to the CECOS network covered all sperm banking activities in patients with cancer. Nevertheless, we were not able to obtain through this network the total number of patients with cancer, and consequently we were not able to estimate the proportion of patients (especially the youngest) having cryopreservation or the time trends of this practice. As shown in Figure 3A and B, we observed that for the youngest patients (under 15 year old) the practice of cryopreservation started only at the end of the 1980s, with a slow increase for hematologic cancer and a much more pronounced increase for germ-cell tumors. In 2005, the proportion of cancer patients aged under 15 years having cryopreservation was 20% for hematologic cancer and 40% for germ-cell tumors compared with 92% and 90%, respectively, for patients between 15 and 19 year old, although the proportion of very young adolescents (11–14 years) referred to the CECOS had increased over time. Such a discrepancy between cancer incidence and the proportion of adolescents referred for sperm banking points to suboptimal care for young cancer patients.

CONCLUSIONS

Fertility preservation remains a major issue for the future of adolescents and young patients with cancer. The delivery to patients and their parents of complete information on why and how to bank sperm is also important psychologically because of the positive perspectives that it offers (42).

By conducting this large national sample over a long period, we demonstrated that sperm sampling and sperm freezing are possible in adolescents and young adults. Consequently, it appears useful and relevant that such practices should be promoted and harmonized. Efforts must be made toward better training for all health-care providers. It is indeed likely that physicians who are untrained in this kind of conversation do not feel comfortable discussing sexuality and fertility preservation with very young patients and with the parents of these patients, particularly at the time when the diagnosis is announced (43–46).

Our findings also argue that this specific area of AYA fertility preservation should be better organized on a national basis. Pediatric oncologists, reproductive specialists, nurses, and the public health-care system must certainly be encouraged to better inform the youngest patients and their parents about the possibility and effectiveness of cryopreservation, even at a very young age.

Training of cancer and reproductive medicine specialists should be optimized, for example, by successful implementation of continuous process improvement to standardize sperm cryopreservation processes (37). Full collaboration between multidisciplinary teams should be encouraged so that this specific population of young patients can be appropriately informed before they start cancer treatment (47).

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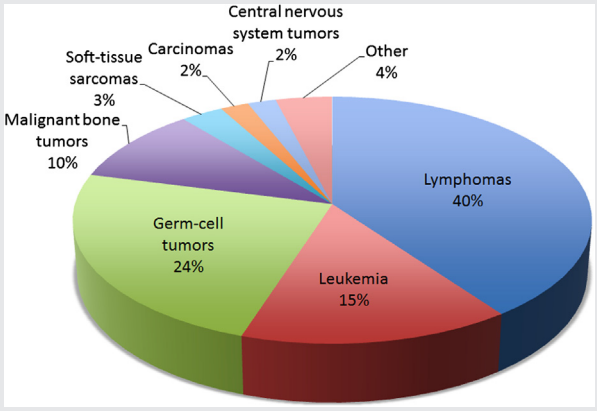
SUPPLEMENTAL FIGURE 1



Types of cancer diagnosed (percentage).

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