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Scalp cooling for hair preservation and associated characteristics in 1411 chemotherapy patients - Results of the Dutch Scalp Cooling Registry

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Abstract

Background. Chemotherapy-induced alopecia is a frequently occurring side effect of cancer treatment with a high psychological impact which can be prevented by scalp cooling. With this multi-centre patient series we estimated the results of scalp cooling for currently used chemotherapies to provide patient information and we identified characteristics associated with the results. *Material and methods.* The Dutch Scalp Cooling Registry collected data on scalp-cooled patients in 28 Dutch hospitals. Nurses and patients completed questionnaires on patients, chemotherapy and scalp cooling characteristics. Logistic regression analysis was used to examine associated characteristics of the scalp cooling result. *Results.* Overall, 50% of the 1411 scalp-cooled patients did not wear a head cover during their last chemotherapy session. Patients were satisfied with the results in 8% of cases after TAC chemotherapy and up to 95% after paclitaxel treatment. Besides type of chemotherapy, higher dose and shorter infusion time, older age, female gender and non-West-European type of hair significantly increased the proportion head cover use. Hair length, quantity, chemical manipulation (dyeing, waving, colouring), wetting hair before scalp cooling, and treatment with chemotherapy ever before did not influence the degree of head covering among patients. *Conclusions.* Scalp cooling results as recorded in this open patient registry were positive for most regimens, justifying it's use by all eligible patients, except for those needing TAC. Lengthening infusion time may improve the results.

Chemotherapy-induced alopecia (CIA) is a common side effect of cancer treatment and one of the most distressing side effects for many patients [1,2]. CIA may be prevented by scalp cooling prior to, during and some time after chemotherapy infusion. Scalp cooling has been practised since the 1970s but the physiological and biochemical aspects have scarcely been modelled [3]. Until 2011 only 48 publications focussed on scalp cooling results [4–11], largely from monocentric studies with small patient numbers. Generally, efficacy is exhibited, although it is not defined uniformly and is inconclusive for most of the currently used chemotherapies. In fact, determinants of scalp cooling results vary tremendously, i.e. especially type, dose and frequency of chemotherapy infusion, the type of scalp cooling equipment and duration [6].

Clinical impressions of oncologists and nurses are often insufficient for predicting the scalp cooling result for a patient needing a particular chemotherapy regimen [12]. Systematic registration of all patients receiving chemotherapy and scalp cooling aims to standardise and clarify the various issues of hair preservation in currently used chemotherapies.

Material and methods

The Dutch Scalp Cooling Registry started in January 2006 with eight community hospitals and one academic hospital. In December 2009, the registry

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comprised 28 hospitals, two of which were academic hospitals. Nurses asked all patients who started scalp cooling in that time period to participate, i.e. chemonaive as well as patients with chemotherapy ever before. Nurses reported the year of birth, gender, cancer type, chemotherapy type, dose and infusion time, the adjuvant or palliative nature and reasons for stopping scalp cooling. Infusion times depended on the protocol of a particular hospital. Some of the examined chemotherapies were sequential schemes.

During the first scalp cooling session patients reported hair characteristics: the length and quantity, the type of hair determined by ethnical background, and whether they had dyed, waved or coloured it within two months of the start of chemotherapy. Patients also stated whether they had received alopecia-inducing chemotherapy ever before. During each session nurses recorded the scalp cooling times and whether they had dampened the patient's hair or used hair conditioner before the start of scalp cooling, thus trying to achieve a lower scalp skin temperature. Tolerance was evaluated by recording reasons for stopping scalp cooling.

Scalp cooling was performed using the Paxman PSC1 or PSC2 system. The result was evaluated by asking patients whether or not they wore a head cover (including wig) during their last scalp cooling session. Head cover use is the most important outcome measure, because it represents perceived satisfaction with hair preservation by scalp cooling; for some patients with minimal CIA, this is a severe burden so they choose to wear a head cover, but the opposite is also true. The result of scalp cooling was also evaluated by patients indicating the severity of hair loss on the WHO scale, with score 0 for none, 1 for minimal, 2 for severe and 3 for total alopecia [13]. Final analyses included only patients who had completed at least two scalp cooling sessions or if they discontinued scalp cooling because of severe CIA after the first session.

Statistics

Differences between patients with and without head covering were compared by the χ^2 test or Mann Whitney U test. Whether the patient, chemotherapy and scalp cooling characteristics were associated with not wearing head covering after scalp cooling was evaluated by logistic regression analyses and expressed as Odds Ratios (OR). In these overall analyses chemotherapy dosages were not taken into account, because of too much variance within the regimens. For the largest subgroup, i.e. women treated with 5-fluorouracil, epirubicine and cyclophosphamide (FEC) chemotherapy (with epirubicine dosages from 50–100 mg/m^2) separate regression analyses were performed, now including dosage. The various patient, chemotherapy and scalp cooling characteristics, included for adjustment in the multivariate analyses, were determined a priori [14]. Statistical differences were indicated if $p < 0.05$ and reported p-values were two-sided. Statistical analyses were performed using SAS (version 9.1 for Windows, SAS institute Inc., Cary NC, USA).

Results

Between 2006 and 2009 1411 patients were registered in the Dutch Scalp Cooling Registry (Table I). The majority of patients were women (96%) with breast cancer (86%), who were treated in the adjuvant setting (69%). The mean age was 53 years (range 18–81 years). The median pre-infusion cooling time was 38 minutes (Standard Deviation (SD) 12, range 3–115) and the median post-infusion cooling time was 90 minutes (SD 17, range 15–210) (data not shown). The median number of cooling sessions was 4 (SD 3, range 1–27).

Half of the patients (n = 709, 50%) wore no head cover during the last scalp cooling session (Table II). Use of head covering varied according to type and dose of chemotherapy from 8% to 94% of patients. Results were best for monotherapy with low dose taxanes: 94% of patients on docetaxel (D75) wore no head cover, as well as 81% of patients with paclitaxel (T70-90) chemotherapy. Results were worst for TAC chemotherapy (8%), despite the relatively low dose of taxane (D75) and anthracycline (A50). In the multivariate analysis, these chemotherapy regimens (D, T and TAC), together with irinotecan, independently influenced the scalp cooling result (Table III). WHO scores for alopecia (WHO 0, 1, 2, 3) for patients wearing head covering, were 2%, 2%, 9% and 87%, respectively, and for patients not wearing head covering 26%, 49%, 25% and 0%.

Multivariate analysis, including all patients, showed that elderly patients (OR 0.6, $p = 0.04$) and those with Asian type of hair (OR 0.4, $p = 0.008$) exhibited the worst scalp cooling results (Table III). Similar results were found for the more homogeneous group of women receiving FEC chemotherapy (Table IV). Male gender was positively associated (OR 6.3, $p = 0.0004$) (Table III). When using WHO scores 0 and 1 ('no/ minimal') versus WHO 2 and 3 ('severe/ total' alopecia) multivariate analyses showed similar results.

The subgroup analysis of patients receiving FEC showed that increase in dosage led to inferior scalp cooling results (Table IV). The indication of a dose-effect relationship was also observed when comparing D75 to D100 (94% vs. 61% no head cover) and T70-100Carbo to T175Carbo (75% vs. 38% no

Table I. Result of scalp cooling according to patient and scalp cooling characteristics (n = 1411).

Characteristics	All patients (%)	No head cover/all (%)	p-value
Overall	1411 (100)	709/1411 (50)	
Age group			0.02
≤ 44 (n = 287)	287 (21)	124/287 (43)	
45–54 (n = 492)	492 (35)	269/492 (55)	
55–64 (n = 413)	413 (30)	207/413 (50)	
65 + (n = 201)	201 (14)	95/201 (47)	
Missing	18		
Gender			< 0.0001
Male	50 (4)	40/50 (80)	
Female	1357 (96)	665/1357 (49)	
Missing	4		
Cancer			< 0.0001
Breast	1216 (86)	598/1216 (49)	
Female genital cancer	65 (5)	30/65 (46)	
Gastro-intestinal/colorectal	63 (4)	25/63 (40)	
Lung	19 (1)	15/19 (79)	
Prostate	27 (2)	27/27 (100)	
Other	16 (1)	12/16 (75)	
Missing	5		
Chemotherapy setting			0.0008
Adjuvant	979 (71)	460/979 (47)	
Palliative	404 (29)	230/404 (57)	
Missing	28		
Chemotherapy ever before			0.007
Yes	176 (12)	105/176 (60)	
No	1235 (88)	603/1235 (49)	
Hair characteristics			
Dyed			0.8
Yes	131 (9)	64/131 (49)	
No[a]	1280 (91)	644/1280 (50)	
Waved			1.0
Yes	42 (3)	21/42 (50)	
No[a]	1369 (97)	687/1369 (50)	
Coloured			0.2
Yes	461 (33)	219/461 (48)	
No[a]	950 (67)	489/950 (51)	
Length			0.02
< 5 cm	379 (30)	210/379 (55)	
> 5 cm	864 (70)	416/864 (48)	
Missing	168		
Quantity			0.1
Small	60 (5)	38/60 (63)	
Medium	597 (48)	294/597 (49)	
Large	587 (47)	289/587 (49)	
Missing	167		
Type of hair			0.07
African	11 (1)	4/11 (36)	
Asian	40 (3)	13/40 (33)	
West-European	1160 (93)	596/1160 (51)	
South-European	39 (3)	17/39 (44)	
Missing	161		
Wetting hair before scalp cooling by			
Dampen hair			0.8
Yes	182 (13)	93/182 (51)	
No[a]	1229 (87)	615/1229 (50)	
Use hair conditioner			0.9
Yes	77 (5)	39/77 (51)	
No[a]	1334 (95)	669/1334 (50)	

[a]'No' includes missings.

Table II. Head cover use during the last scalp cooling session according to type of chemotherapy.

Chemotherapy and planned dosage (mgr/m^2)[a]	No head cover/total (%)	Median infusion time (min.) (SD/min/max)	Number of sessions planned[d]
A60C600 (AC)	29/74 (39)	30 (13/10/90)	4
A60C600/D100[b] (ACD)	10/16 (63)	20 (11/10/40)/60 (0/60/60)	4/4
ACT Overall	20/50 (40)		
A60C600/T80[b] (ACT80)	14/29 (48)	30 (15/10/75)/60 (31/60/180)	4/12
A60C600/T175[b] (ACT175)	6/21 (29)	30 (22/20/120)/180 (0/180/180)	4/4
D75A50C500 (TAC)	5/66 (8)	90 (14/45/135)	6
D Overall[f]	87/120 (73)		
D75	31/33 (94)	60 (0/60/60)	n.a.
D100	27/44 (61)	60 (8/60/90)	n.a.
D75combi[c]	21/33 (64)	105 (26/60/150)	n.a.
F500A50C500 (FAC)	21/39 (54)	45 (13/25/90)	5
FEC Overall[f]	371/752 (56)		
F500E50-70C500 (FE50-70C)	22/38 (58)	45 (9/25/75)	5
F500/600E75-85C500/600 (FE75-85C)	16/32 (50)	45 (10/25/60)	5
F500E90C500 (FE90C)	292/558 (52)	45 (16/15/120)	5
F500/600E100C500/600 (FE100C)	40/123 (33)	45 (14/15/90)	6
F500E100C500/D100[b] (FE100CD)	22/46 (48)	60 (21/15/90)/60 (12/60/140)	3/3
TCarbo Overall[f]	31/68 (46)		
T70-100Carbo	9/12 (75)	120 (31/90/210)	n.a.
T175Carbo	20/52 (38)	210 (31/90/240)	6
T70-90	34/42 (81)	60 (28/60/180)	n.a.
Irino350	12/42 (29)	60 (24/30/90)	n.a.
Other[e]	49/64 (77)		
Total	709/1411 (50)		

[a]Dosage other/missing, but included in multivariate analyses: TAC n = 1, FAC n = 4, FECD n = 6, T n = 2, Irino n = 5.
[b]Sequential scheme.
[c]D combi: D combined with Cyclophosphamide, Capecitabine, Carboplatin, Gemcitabine, Methotrexaat, Myocet or Xeloda.
[d]According to Dutch guidelines.
[e]Other: < 10patients had a particular regimen with a specific dosage.
[f]Including also other dosages than specified in this table.
A: doxorubicine; Carbo: carboplatin; C: cyclophosphamide; D: docetaxel; E: epirubicine; F: 5-fluorouracil; Irino: irinotecan T: paclitaxel. All 3-weekly schemes, with exception of /T80 and T70-90.

head cover) (Table II). Longer FEC infusion times reduced the use of head covering (Table IV). This effect was also observed marginally for the total patient group (Table III).

Patients with chemically manipulated hair because of dying, waving or colouring did not exhibit higher head cover use after scalp cooling, neither did those with longer length and larger quantities of hair or longer post-infusion cooling times (Tables III and IV). Wetting hair also did not contribute to the result. Corrected for the type of chemotherapy in the multivariate analysis, the results were better for patients who had had no chemotherapy before.

Scalp cooling was stopped because of intolerance in only 3% of patients. No scalp skin metastases were reported following the last chemotherapy session up to August 2011.

Discussion

To our knowledge this is the largest prospective multicentre patient series on scalp cooling among patients receiving chemotherapy reported in the literature and the first one to study multivariate characteristics associated with head cover use after scalp cooling. The Dutch Scalp Cooling Registry data showed that no head cover was used by 50% of patients who received chemotherapy regimens that normally cause severe CIA. This outcome is not very optimal; however when a patient has a 50% chance to keep their hair during chemotherapy, it will be an incentive for many patients to choose scalp cooling. Our results are in accordance with the literature, when comparing corresponding dosages [6]. However, in our registry dosages were generally higher than in several recent studies [15–19] and several new chemotherapy regimens were evaluated. Since all scalp-cooled patients in the hospitals could participate, significant patient groups with a specific chemotherapy regimen emerged, which properly reflected daily practice at day care units.

The outcome parameters – proportion head cover use and WHO score – are only an indication of scalp cooling efficacy. For example, patients receiving docetaxel were twice as likely to wear no head cover as patients on FEC (OR 2.0 vs. 1.0). However, scalp

Table III. Univariate and multivariate logistic regression analysis of all patients (n = 1411); odds of wearing no head cover during the last scalp cooling session (hc) and odds of WHO score 0-1 (who).

		Multivariate			
Characteristics	Univariate OR (hc)	OR (hc)	95% CI	P-value	OR (who)
Age group (years)					
≤44	1.0	1.0	–	–	1.0
45–54	1.5	1.3	(0.9–1.8)	0.1	1.2
55–64	1.2 (NS)	1.1	(0.7–1.5)	0.8	1.1
65+	1.1 (NS)	0.6	(0.4–1.0)	0.04	0.8
Gender					
Female	1.0	1.0	–	–	1.0
Male	4.2	6.3	(2.3–17.2)	0.0004	9.4[c]
Chemotherapy					
FEC	1.0	1.0	–	–	1.0
AC	0.7 (NS)	1.0	(0.6–1.7)	0.9	0.6
AC/D	1.7 (NS)	1.7	(0.5–5.2)	0.4	1.4
AC/T	0.7 (NS)	1.2	(0.6–2.5)	0.6	0.9
TAC	0.08	0.08	(0.03–0.2)	<0.0001	0.04[c]
D[b]	2.7	2.0	(1.2–3.5)	0.01	1.6
FAC	1.2 (NS)	1.2	(0.6–2.5)	0.6	1.7
FEC/D	1.0 (NS)	0.9	(0.4–1.9)	0.8	1.1
TCarbo	0.9 (NS)	1.1	(0.5–2.4)	0.8	1.1
T	3.4	4.6	(2.1–10.2)	0.0002	4.3[c]
Irino	0.4	0.3	(0.1–0.7)	0.004	0.2[c]
Other	3.2	4.9	(2.3–10.3)	<0.0001	4.3[c]
Infusion time[a] (minutes)					
0–15	1.0	1.0	–	–	1.0
16–30	0.8 (NS)	1.2	(0.6–2.4)	0.6	0.9
31–45	1.0 (NS)	1.5	(0.8–2.8)	0.2	1.3
46–60	1.5 (NS)	1.8	(1.0–3.3)	0.07	1.5
61–90	0.7 (NS)	1.8	(0.9–3.7)	0.09	1.8
90+	0.9 (NS)	1.6	(0.7–3.4)	0.2	1.2
Chemotherapy ever before	1.6	0.8	(0.6–1.3)	0.4	1.0
Dyed					
No	1.0	1.0	–	–	1.0
Yes	1.0 (NS)	0.9	(0.6–1.3)	0.6	0.9
Waved					
No	1.0	1.0	–	–	1.0
Yes	1.0 (NS)	1.2	(0.6–2.3)	0.7	1.1
Coloured					
No	1.0	1.0	–	–	1.0
Yes	0.9 (NS)	0.9	(0.7–1.1)	0.3	1.0
Length					
≥5 cm	1.0	1.0	–	–	1.0
larger/equal 5 cm	0.7	0.9	(0.7–1.1)	0.3	0.9
Quantity					
Small	1.0	1.0	–	–	1.0
Medium	0.6	0.6	(0.4–1.2)	0.09	0.8
Large	0.6	0.7	(0.3–1.1)	0.2	0.9
Type of hair[a]					
West-European	1.0	1.0	–	–	1.0
South-European	0.7 (NS)	0.6	(0.3–1.3)	0.2	0.7
African	0.5 (NS)	0.4	(0.1–1.6)	0.2	0.3
Asian	0.5	0.4	(0.2–0.8)	0.008	0.5
Mean post infusion cooling time (minutes)					
0–80	1.0	1.0	–	–	1.0
81–100	0.9 (NS)	0.6	(0.6–1.2)	0.3	0.9
101+	1.0 (NS)	0.7	(0.7–1.6)	0.9	0.8

(*Continued*)

Table III. (*Continued*).

Characteristics	Uni variate OR (hc)	Multivariate			OR (who)
		OR (hc)	95% CI	P-value	
Wetting hair before scalp cooling by					
Dampen hair					
No	1.0	1.0	–	–	1.0
Yes	1.0 (NS)	1.2	(0.8–1.7)	0.4	1.4
Use hair conditioner					
No	1.0	1.0	–	–	1.0
Yes	1.0 (NS)	1.1	(0.7–1.9)	0.6	1.0

[a]missings included in analysis.
[b]D: mono and combination chemotherapy.
[c]Significantly associated.
A: doxorubicine; Carbo: carboplatin; CI: confidence interval; C: cyclophosphamide; D: docetaxel; E: epirubicine; F: 5-fluorouracil; I: irinotecan; NS: non-significant; OR: odds ratio; T: paclitaxel.

cooling improved the chance of no head covering in FEC from about 5% [12] to 49% (factor 10) and in docetaxel from about 30% [20] to 75% (factor 2.5). The net scalp cooling efficacy remains unknown for most chemotherapy regimens, while severity of CIA without scalp cooling was not evaluated and varies tremendously in phase II and III trials.

Less head cover use after longer infusion times has not been reported previously. It seems that a lower peak plasma concentration causes more damage to hair root cells than a longer chemotherapeutic exposure time. Lengthened infusion times are regularly used to prevent hypersensitivity reactions and to lower the risk of cardiotoxicity [21,22]. However, variation in infusion time may alter treatment outcomes and toxicity differently in each regimen [23,24].

The finding that after scalp cooling patients older than 65 years were more likely to wear a head cover is new. Only Macduff et al. reported in a small study that patients aged 50 or over lost more hair than those younger than 50 years [25]. It is possibly due to higher chemotherapeutic concentrations in hair root cells during scalp cooling. Aged skin has a diminished cold-induced vasoconstriction [26] and an age-related decline in organ function may increase toxicity [27]. Chemotherapeutics mainly affect anagen hairs, i.e. hair in the growth phase, and cause a sharp constriction of the hair shaft, where hairs may break [28]. Therefore, the reduced hair diameter at older age may also increase the risk of breakage.

Reduced scalp cooling results for Asian patients may be caused by a lower maximum tolerable chemotherapeutic dose and higher toxicity rates compared to their Western counterparts [29]. The satisfactory scalp cooling results reported in a recent Japanese study may be attributed to lower chemotherapy dosages (T60, C400, E40) than currently used in the Netherlands [17]. Biochemical characteristics of hair from people of different ethnical backgrounds have proved to be very similar, whereas geometry, mechanical properties and phase and rate of hair growth are particularly different [30–33]. These factors might contribute to hair breakage rates.

Unsatisfied scalp-cooled patients exhibited overall worse quality of life and body image compared to patients who did not undergo scalp cooling [1]. Therefore, scalp cooling should not be advised if poor results are expected, i.e. up to now with TAC.

The unspecified patient group with very diverse chemotherapy regimens had good scalp cooling results. The regimens and dosages for this group might have caused somewhat less often severe CIA, also without scalp cooling.

The good scalp cooling results for males may be caused by a difference in chemotherapy. Males most frequently received docetaxel 75 mg/m^2 (52%), for which scalp cooling results are particularly good [20]. Moreover, the result in males is likely to be somewhat overestimated, since they are in general less inclined to wear a wig or head cover. The low number of male patients is not because they do not value their hair [34], but probably because scalp cooling is rarely offered to them. In one of our studies all eligible patients were actively recruited and one third of the 168 scalp-cooled patients were males [20].

Continuous multicentric registration ensures rapid availability of the scalp cooling results patients may expect in new or uncommon chemotherapy regimens. Furthermore, registration may be used to detect easily differences in results between hospitals; actions may be undertaken in case of extra good outcomes or if outcomes are below average. As found in the past in the Netherlands, several hospitals quickly stopped scalp cooling after disappointing results in a minimal number of patients.

In conclusion, for daily practice this study implies that scalp cooling results are better with certain chemotherapy types (taxanes), decrease at higher doses and might be improved by longer infusion

Table IV. Univariate and multivariate logistic regression analysis of females with breast cancer, receiving FE50C-FE100C chemotherapy (n = 751); odds of wearing no head cover during the last scalp cooling session.

			Multivariate		
FEC50-100	n =	Univariate OR	OR	95% CI	p-value
FEC dosage epirubicine (mgr/m^2)					
50–70	38	1.0	1.0	–	–
75–85	32	0.7 (NS)	0.7	(0.3–1.9)	0.5
90	558	0.8 (NS)	0.6	(0.3–1.3)	0.2
100	122	0.3	0.3	(0.1–0.6)	0.002
Age group (years)					
≤ 44	163	–	1.0	–	–
45–54	305	1.4 (NS)	1.4	(0.9–2.1)	0.2
55–64	216	1.1 (NS)	1.1	(0.7–1.8)	0.7
65 +	61	0.6 (NS)	0.4	(0.2–0.8)	0.01
Infusion time[a] (minutes)					
0–15	34	1.0	1.0	–	–
16–30	82	1.9 (NS)	2.3	(0.9–5.8)	0.08
31–45	309	2.9	2.9	(1.2–6.7)	0.01
46–60	188	3.0	3.1	(1.3–7.3)	0.01
61–90	39	4.4	5.4	(1.8–16.0)	0.002
Chemotherapy ever before	39	0.8 (NS)	0.6	(0.3–1.3)	0.2
Chemically damaged hair					
Dyed	71	0.7 (NS)	0.6	(0.4–1.1)	0.09
Waved	21	0.8 (NS)	1.2	(0.4–3.3)	0.7
Coloured	279	0.9 (NS)	0.9	(0.6–1.2)	0.5
Length					
< 5 cm	191	1.0	1.0	–	–
≥ 5 cm	475	0.9 (NS)	1.0	(0.7–1.4)	0.9
Quantity					
Small	27	1.0	1.0	–	–
Medium	306	0.8 (NS)	0.7	(0.3–1.6)	0.3
Large	331	0.9 (NS)	0.8	(0.3–1.8)	0.5
Type of hair					
West-European	627	1.0	1.0	–	–
African/Asian/South-European	37	0.5	0.5	(0.2–1.0)	0.05
Mean post infusion cooling time (minutes)					
0–80	59	–	1.0	–	–
81–100	502	1.2 (NS)	1.0	(0.6–1.8)	0.9
101 +	167	1.4 (NS)	1.4	(0.8–2.7)	0.3
Wetting hair before scalp cooling by					
Dampen hair					
No	654	1.0	1.0	–	–
Yes	96	1.0 (NS)	1.0	(0.6–1.7)	0.9
Use hair conditioner					
No	700	1.0	1.0	–	–
Yes	50	1.0 (NS)	1.0	(0.5–1.9)	1.0

[a]missings included in analysis.
CI: confidence interval; C: cyclophosphamide; E: epirubicine; F: 5-fluorouracil; NS: non-significant; OR: odds ratio.

times. Medical doctors and nurses have to be aware that males are also eligible for scalp cooling and those patients of older age or non-West-European hair type may have somewhat less chance of satisfactory results. Scalp cooling results need to be improved, mainly by a more patient-tailored approach. Progress can be achieved by a better patient selection and when optimal scalp skin temperature and cooling times for each type of chemotherapy are known. Scalp cooling intensity should be adapted to the optimal scalp skin temperature for each patient. Post-infusion cooling times (PICT) are currently only used arbitrarily, with the exception of docetaxel [20]. Optimal PICTs may vary in particular chemotherapy regimens, while half life times of chemotherapeutics vary tremendously. We continued multicentre registration, because it improved patient information while analysis of characteristics provided a better understanding of the determinants that improve scalp cooling results. This registry should be expanded internationally to obtain a consistent picture.

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