ORIGINAL ARTICLE

Increased prevalence of left-sided skin cancers

Susan T. Butler, MD,[a] and Scott W. Fosko, MD[a,b,c,d,e]
Saint Louis, Missouri

Background: Previous research has shown an increase in photodamage and precancers on the left side of the face.

Objective: We sought to determine whether there is a higher frequency of skin cancer development on the left side of the body than the right.

Methods: The study was a retrospective review of patients with skin cancer referred to our Mohs micrographic surgery and cutaneous oncology unit in 2004.

Results: When including all types of skin cancers and both sexes, more cancers occurred on the left (52.6%) than the right (47.4%) (P = .059), with a stronger trend in men (P = .042). There were significantly more malignant melanoma in situ on the left (31/42, 74%) than the right (11/42, 26%) (P = .002).

Limitations: Population was comprised of patients referred to an academic medical center and often for Mohs micrographic surgery.

Conclusions: There were significantly more skin cancers on the left than the right side in men. This discrepancy was even more profound in malignant melanoma in situ. (J Am Acad Dermatol 10.1016/j.jaad.2009.11.032.)

Key words: left sided; photodamage; skin cancer; ultraviolet A.

Currently, between 2 and 3 million nonmelanoma skin cancers and 132,000 melanoma skin cancers occur globally each year.[1] Ultraviolet (UV) exposure is a major causative factor in melanoma and nonmelanoma skin cancer. UV radiation is comprised of UVA and UVB rays. UVA rays are able to penetrate glass windows whereas UVB rays cannot. Automobile drivers are exposed to a significant amount of UVA rays that penetrate driver's side window glass or pass easily through open windows, sunroofs, or convertible tops. In our own and others' personal experience in the United States, it has been observed that significant photodamage, precancers, and possibly skin cancers were occurring on the driver's side or left side of the face.

Abbreviations used:

LM:	lentigo maligna
MMIS:	malignant melanoma in situ
UV:	ultraviolet

A previous study by Singer et al[2] showed an asymmetry of photodamage on the face, and a correlation between left-sided photodamage and percentage of time spent as the driver. The photoaging effects of UVA can also be demonstrated through a striking case study of an office worker with extensive Favre-Racouchot disease on her left cheek, which faced her office window for 15 years, but virtually no photodamage on the contralateral side. Because UVB does not pass through window glass, this observation identifies the role of UVA in photoaging.[3] A study performed in Australia found an increase in incidence of precancers on the side of

From the Departments of Dermatology,[a] Otolaryngology,[b] Ophthalmology,[c] and Internal Medicine,[d] Saint Louis University School of Medicine; and the Saint Louis University Cancer Center.[e]

Funding sources: None.
Conflicts of interest: None declared.
Portions of these data were included in a poster presentation entitled "The Association of Asymmetric Skin Cancers with Time Spent in an Automobile" at the American Academy of Dermatology Annual Meeting, February 1-5, 2007, Washington, DC.
Accepted for publication November 9, 2009.

Reprint requests: Susan T. Butler, MD, Department of Dermatology, Saint Louis University, 1402 S Grand Blvd, Saint Louis, MO 63104. E-mail: suzybutler1@gmail.com.

Published online March 10, 2010.
0190-9622/$36.00

doi:10.1016/j.jaad.2009.11.032

the body correlating to the side of the car subjects most frequently sat on. Men formed more actinic keratoses on the right side, whereas women formed more on the left side (driver's side is on right in Australia).[4] This supports the association of UV exposure and subsequent evidence of clinical damage to the occupant's exposed side of the face.

No studies to date have shown that more skin cancers form on the left side of the body than the right for countries where driving habits are similar to those in the United States. The goal of this study was to determine whether there is a higher frequency of skin cancer development on the left side of the body than on the right.

CAPSULE SUMMARY

- There are more skin cancers occurring on the left side of the body than the right.
- This trend is more pronounced in men and in certain cancers such as melanoma in situ.
- This finding may be explained by ultraviolet exposure to the left side of the body while driving.

METHODS

This study was approved by our institutional review board (No. 14844). The design was a retrospective review of all patients referred to the Mohs micrographic surgery and cutaneous oncology unit at our university department of dermatology between January 2004 and December 2004.

Information was collected regarding the type of skin cancer, location of the skin cancer on the body, and age and sex of the patients. Patients were excluded if their skin cancer was located along the midline of the body, or if their medical records were unavailable or incomplete.

RESULTS

The charts of 1047 patients were reviewed. Of the 890 patients who had non-midline skin cancers, 557 (63%) were male and 333 (37%) were female (P = .001). The mean age was 68 years. Basal cell carcinoma was the most common type of skin cancer with a total of 608 (68.3%) (Table I). The next most common cancer was squamous cell carcinoma occurring in 178 (20.0%) patients, followed by malignant melanoma in situ (MMIS) in 42 (4.7%) patients, squamous cell carcinoma in situ in 38 (4.3%) patients, and invasive malignant melanoma in 23 (2.6%) patients. The MMIS group was composed of both lentigo maligna (LM) and superficial spreading subtypes. Of note, the melanomas and MMIS were not treated by the Mohs micrographic technique, rather by wide local excision and permanent section confirmation of margins.

The most common location for skin cancer was the head/neck with 731 (82.1%) occurrences. The next most common location was the arm with 59 (6.6%) occurrences, followed by the leg with 30 (3.4%), and the hand with 27 (3.0%) cancers (Table II).

When including all types of skin cancers and both sexes, more cancers did occur on the left (52.6%) than the right (47.4%) (P = .059). When dividing by sex, there were significantly more skin cancers on the left (301) than on the right (256) in male patients only (P = .042). There was no significant difference noted in female patients (Fig 1).

The cancers occurring on the head and neck were analyzed separately as these areas are most directly exposed to UV rays while driving. The left-sided predominance was even more pronounced when looking at only these sites in both sexes, with the percentage of skin cancers on the left increasing from 52.6% (468/890) to 54.0% (395/731). This predominance was only statistically significant in male patients, who showed a greater increase from 54.0% (301/557) to 55.8% (255/457) (P = .017).

When including only MMIS, there were significantly more cancers on the left (31/42, 74%) than the right (11/42, 26%) (P = .002) (Fig 2). This trend was consistent in both sexes, although stronger in men (17/22, 77%) compared with women (14/20, 70%).

DISCUSSION

For all cancers in both men and women, a left-sided distribution was seen. There were significantly more skin cancers formed on the left side of the body than the right in men and especially of the exposed areas of the head and neck. There was no significant difference observed in women. Several explanations for these findings may exist. Increased exposure to UV rays during driving may lead to the development of more skin cancers on the left side of the body. Previous research has shown that the left side of the head, neck, arm, and hand receive up to 6 times the dose of UV radiation as the right side in those sitting on the left side of the car.[5] Our findings further support this hypothesis, as there was a slightly larger discrepancy between left- and right-sided skin cancers in those cancers occurring on the head and neck. There were 54% left-sided cancers when just including head and neck locations versus 52.6% left-sided cancers for all locations. It is also interesting to note that when examining the distribution of skin cancer location for both sides, 82% (731/890)

Table I. Skin cancer types by sex and side of body

	Male	Female	Left	Right	Total	Percent
BCC	369	239	311	297	608	68.3
SCC	126	52	97	81	178	20.0
MMIS	23	19	31	11	42	4.7
SCCIS	24	14	22	16	38	4.3
MM	14	9	7	16	23	2.6
Total	557 (63%)	333 (37%)	468 (53%)	422 (47%)	890	100

BCC, Basal cell carcinoma; *MM*, malignant melanoma; *MMIS*, malignant melanoma in situ; *SCC*, squamous cell carcinoma; *SCCIS*, squamous cell carcinoma in situ.

Table II. Location of skin cancer by sex

	Male		Female			
Anatomic location	Left	Right	Left	Right	Total	Percent of population
Head and neck	255	202	140	134	731	82.1
Arm	21	23	7	8	59	6.6
Hand	9	10	3	5	27	3.0
Foot	0	1	0	1	2	0.2
Back	7	9	3	4	23	2.6
Chest	5	8	1	4	18	2.0
Leg	4	3	13	10	30	3.4
Total	301	256	167	166	890	100

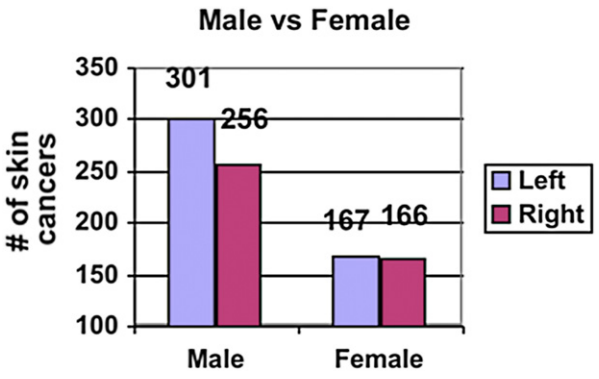

Fig 1. Skin cancers on left versus right side of body by sex.

occurred on the sun-exposed areas of the head and neck and this increased to 92% (817/890) when including the arm and hand locations (Table II).

Most of the UV exposure while driving affects the head and neck locations, so this finding supports a potential role for the sun exposure gained while driving. The side windows of automobiles are made of nonlaminated clear glass, which blocks UVB but allows 63% transmission of UVA.[6] Though UVB has traditionally been recognized as a contributing factor in skin cancer formation, there have been no conclusive studies regarding the role of UVA. In vivo studies have shown that UVA alone can induce mutations in human DNA,[7,8] and observational studies have recognized an increased risk of melanoma in patients receiving large doses of UVA from tanning beds or in combination with psoralen.[9] Our observations that significantly more MMIS occur on the side of the body exposed consistently to UVA penetrating car window glass suggest that cumulative UVA exposure over years may indeed play an important role in the development of this cutaneous malignancy. The significant left-sided predominance of MMIS in this study was striking and has prompted further investigation into this finding (Tables III and IV). Future studies are planned with increased numbers in this subgroup to confirm this observation and further study the potential photocarcinogenic role of UVA in MMIS.

Interestingly, our invasive melanomas demonstrated a right-sided predominance (70%, 16/23). Although the overall number of invasive melanoma is low, this raises the possibility that both the type of UV exposure, chronic versus intermittent, and body location, sun exposed versus sun protected, may play a role in the subtype of melanoma development and its site of occurrence. Curiously, this may also suggest that chronic sun exposure may have a protective effect in the development of invasive melanoma. Our study was not designed to address this possibility and our overall patient numbers for melanoma are small and a significant limitation to any interpretation. This observation is striking in our cohort and deserves further study. Chang et al[10] and others have reported

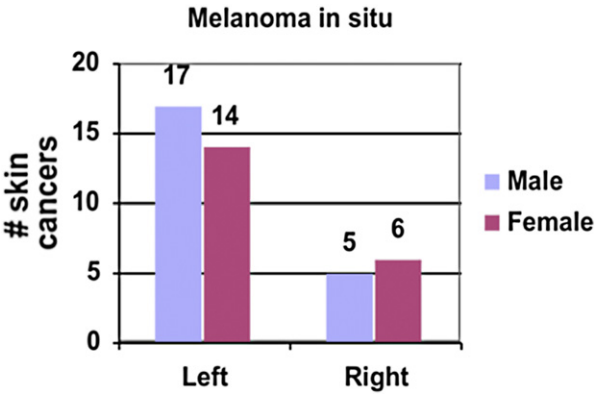

Fig 2. Melanoma in situ on left versus right side of body by sex.

Table III. Melanoma in situ and invasive melanoma by sex and side of body

	Male	Female	Left	Right	Total
MMIS	22	20	31	11	42
MM	14	9	7	16	23
Total	36 (55%)	29 (45%)	38 (58%)	27 (42%)	65

MM, Malignant melanoma; *MMIS*, malignant melanoma in situ.

Table IV. Anatomic locations for melanoma in situ and invasive melanoma

	MMIS		Melanoma		Total	
Anatomic location	Left	Right	Left	Right	MMIS	MM
Head and neck	25	9	2	3	34	5
Arm	1	0	3	8	1	11
Hand	0	1	0	0	1	0
Back	5	1	1	3	6	4
Chest	0	0	0	1	0	1
Leg	0	0	1	1	0	2
Total	31	11	7	16	42	23

MM, Malignant melanoma; *MMIS*, malignant melanoma in situ.

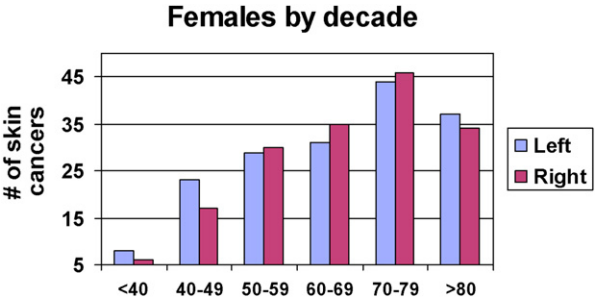

Fig 3. Location of skin cancer in female patients by age.

a relationship of melanoma body site distribution to patterns and amounts of sun exposure, with recreational intermittent sun exposure associated with melanomas of the trunk and occupational continuous sun exposure with melanomas of the head and neck. This meta-analysis did not include melanomas in situ, but did include LM melanomas. Others have reported that the pattern of sun exposure is related to the risk of invasive melanoma development, with intermittent, intense periods of exposure associated with an overall increased risk, and more chronic, continuous exposures with a decreased risk of invasive melanoma development.[11-13]

The sex difference observed in our data may be explained by differences in driving behaviors between men and women. In this study, women did not show a significant left-sided predominance of skin cancers. However, when dividing the data by decade, it was noted that younger women (<50 years) did in fact show a left-sided predominance (Fig 3). At age 50 years, this trend reverses as right-sided skin cancers become more common (with the exception of those aged > 80 years). In the subgroup of women younger than 50 years, 31 of 54 or 57% of cancers were on the left side. In women older than 50 years, 141 of 286 or 49% of cancers were on the left side. It is important to note that these numbers are relatively small and that analysis of the subgroups is not statistically significant. This trend may represent a shift in driving behavior by women. Perhaps the older generations have spent more time in the passenger side of the car, receiving more UV radiation to the right side of the body. Although we can only speculate about the driving habits in women, the shift in the trend seen around age 50 years may indicate that women born in 1954 or later have spent more time as the driver, receiving more exposure on the left side of their body. The number of vehicles per household has nearly doubled in the last 25 years, which may affect the amount of time women spend on the driver's side of the car.[14]

It was particularly interesting to find such a significant asymmetry with regard to MMIS. LM, one subtype of MMIS in particular, is known to develop on chronically sun-exposed skin, so it is possible that the higher frequency of left-sided LM is a result of the cumulative exposure to UV rays while driving a car.

The existence of a left-sided trend in both nonmelanoma skin cancer and noninvasive melanomas underlines the importance of minimizing sun exposure while in the car. This can be achieved by laminating or tinting window glass. Clear films can be applied to window glass that block 99.9% of UVA and UVB. One study directly measured cell death upon exposure to UV light, and noted a 93% reduction in cell death when UV exposure was filtered through laminated auto glass.[15] Our data also underline the

importance of wearing a daily sunscreen that blocks both UVA and UVB on all exposed body parts.

One limitation of this study was that our population was limited to patients who were referred to an academic medical center and often for Mohs micrographic surgery. Although this may have led to a higher percentage of skin cancers located on the head and neck, this selected population, however, should not have skewed the frequency of cancers to the left versus the right.

Another factor that may have influenced our data is the predominance of men in our population. The percentage of men in our study is consistent with previously reported incidence rates showing that men have nearly double the number of nonmelanoma skin cancer as women.[16] The tendency of men to sit on the driver's side of the car may have contributed to the number of left-sided skin cancers in our study. There were certainly different trends in skin cancer formation observed when examining the sexes separately.

In summary, there were significantly more skin cancers found on the left than the right side of the body in men. For women, a trend of left-sided predominance was seen and was stronger for those younger than 50 years. This discrepancy was even more profound in MMIS and in all skin cancers occurring on exposed parts of the body, especially the head and neck locations. This left-sided predominance of skin cancers may be in part a result of UV exposure during time spent in an automobile. Future studies need to be conducted to determine if driving behavior is related to skin cancer formation.

The authors are grateful to Evan Jones, MD, and Summer Youker, MD, for early study design; to Elizabeth Duvall, MD, for data collection; to Chris Kling, MD, for preliminary data analysis; to Dana Oliver, MPH, MT (ASCP), for statistical analysis; and to Paula Turdo and Carrie Angus for administrative support.

REFERENCES

1. World Health Organization. Ultraviolet radiation and the INTERSUN Programme. 2005. Available from: URL:http://www.who.int/uv/faq/skincancer/en/index1.html. Accessed January 17, 2009.
2. Singer R, Hamilton T, Voorhees J, Griffiths C. Association of asymmetrical facial photodamage with automobile driving. Arch Dermatol 1994;130:121-3.
3. Moulin G, Thomas L, Vigneau M, Fiere A. Un cas unilateral d'elastose avec kystes et comedons de Favre et Racouchot. Ann Dermatol Venereol 1994;121:721-3.
4. Foley P, Lanzer D, Marks R. Are solar keratoses more common on the driver's side? Br Med J Clin Res 1986;293:18.
5. Moehrle M, Soballa M, Korn M. UV exposure in cars. Photodermatol Photoimmunol Photomed 2003;19:175-81.
6. Hampton PJ, Farr PM, Diffy BL, Lloyd JJ. Implication for photosensitive patients of ultraviolet A exposure in vehicles. Br J Dermatol 2004;151:873-6.
7. Burren R, Scaletta C, Frenk E, Panizzon RG, Applegate LA. Sunlight and carcinogenesis: expression of p53 and pyrimidine dimers in human skin following UVA I, UVA I + II and solar simulating radiations. Int J Cancer 1998;76:201-6.
8. International Agency for Research on Cancer (IARC). A review of human carcinogens—part D: radiation. Vol 10. Available from: URL:http://www.thelancet.com/oncology. Accessed August 28, 2009.
9. Stern RS, Nichols KT, Vakeva LH. Malignant melanoma in patients treated for psoriasis with methoxsalen (psoralen) and ultraviolet A radiation (PUVA): the PUVA follow-up study [see comments]. N Engl J Med 1997;336:1041-5.
10. Chang Y, Barrett JH, Bishop DT, Armstrong BK, Bataille V, Bergman W, et al. Sun exposure and melanoma risk at different latitudes: a pooled analysis of 5700 cases and 7216 controls. Int J Epidemiol 2009;38:814-30.
11. Elwood JM, Gallagher RP, Hill GB, Pearson JG. Cutaneous melanoma in relation to intermittent and constant sun exposure—the western Canada melanoma study. Int J Cancer 1985;35:427-33.
12. Green A, Siskind V, Bain C, Alexander J. Sunburn and malignant melanoma. Br J Cancer 1985;51:393-7.
13. Osterlind A. Malignant melanoma in Denmark: occurrence and risk factors. Acta Oncol 1990;29:833-54.
14. McGuckin N, Liss S. Aging cars, aging drivers: important findings from the national household travel survey. Institute Transportation Engineers 2005;75:30-7.
15. Bernstein EF, Schwartz M, Viehmeyer R, Arocena MS, Sambuco CP, Ksenzenko SM. Measurement of protection afforded by ultraviolet-absorbing window film using an in vitro model of photodamage. Lasers Surg Med 2006;38:337-42.
16. American Cancer Society. Nonmelanoma skin cancer; Atlanta (GA); 2006. Available from: http://documents.cancer.org/118.00/118.00.pdf. Accessed March 24, 2007.