Standardization and Scoring of the Body Surface Area (BSA) Formulas for Calculation of the Doses of Anticancer Agents for Cancer Patients from the North-Western Nigeria

Saganuwan Alhaji Saganuwan1* and Alhaji Muhammadu Ndakotsu2
1Department of Veterinary Physiology, Pharmacology and Biochemistry, College of Veterinary Medicine, University of Agriculture, Nigeria
2Department of Medical Microbiology and Pathology, College of Health Sciences, Usmanu Danfodiyo University, Nigeria

Abstract

Background: Allometric scaling is an empirical examination of the relationship between the pharmacokinetic parameters and body size. Because of the importance of body surface area formulas for calculation of anticancer agents, there is need to standardize and score all the existing body surface area formulas with a view to obtaining the best and most efficient formula that can be adopted for use by our hospitals.

Methods: A total of 33 (10.3%) out of 319 presented to the Haematology Department of Usmanu Danfodiyo University Sokoto, Nigeria were diagnosed of Leukaemia and lymphoma. Cyclophosphamide, daunorubicin, vincristine, adriamycin and chlorambucil were used for the treatments. Eleven (11) of the affected 33 patients were randomly selected for calculation of their body surface area using the formulas of DuBois, Boyd, Gehan and George, Haycock et al., Monsteller, Wang et al., Takashira and Fujimoto. The mean of the results obtained from each formula and for each individual was calculated and compared with all the results provided by the respective formulas and all the formulas scored.

Results: Wang et al. recorded the highest score 21 (21.2%) followed by DuBois 20(20.2%), this paper 18 (18.2%), Monsteller 18 (18.2%), Haycock et al. 14 (14.2%), Boyd 13 (13.1%), Gehan and George 13(13.1%), Takashira 4 (4.0%) and Fujimoto 3 (3.0%).

Conclusion: Wang et al. gives moderate effective anticancer doses and it is therefore recommended for the patients. It provides neither moderate doses of anticancer agents that may cause increased toxicity signs nor high risk of cancer remission.

Keywords: BSA; Anticancer agents; Leukaemia; Standardization; Body weight; Nigeria

Introduction

The safety of drug dosing has become a concern, even for drugs that produce therapeutic effects at doses far lower than those that cause toxicity. Errors in dose calculation of anticancer agents are even a greater concern because of high incidence of serious or life-threatening toxicity associated with many of them. Pharmacologically based or pharmaco-genetically based dosing may be far more rewarding than body surface area based dosing [1].

The DuBois formula, which is the western standard formula, is validated to a greater extent and its accuracy has been confirmed more than others, including the Fujimoto formula. Recommended is the use of the DuBois formula instead of Fujimoto formula in cancer chemotherapy and the standardization of this formula had been proposed in Japan [2]. There is a presumed narrow therapeutic index for most anticancer agents as shown in breast cancer [3,4], testicular cancer [5], lymphoma [6], and other cancers [2]. Selecting doses of anticancer agents to treat cancer patients can be a challenging decision for medical oncologists [2].

In 1916, DuBois and DuBois reported the BSA formula with direct measurements of nine subjects including a 36-years-old cretin with an underdeveloped physique, a 12-year-old boy, a tall thin adult male, and a short, obese adult female [7]. In 1978, Haycock et al. reported another formula based on measurements of 81 Caucasian, African American and Hispanic subjects [8]. In 1984, Martin et al. determined the BSA from 20 aged cadaver subjects by planimetry on paper tracings of dissected skin and compared the measured surface area and recommended continued use of the DuBois formula [9]. In 1987, Monstellar modified the Gehan and George formula [11] and simplified it to enable the calculation using a pocket calculator. In 1992, Wang et al. measured the BSA with 60 pregnant women (34 to 40 week gestation) and 148 neonates [12]. Regardless of these highly varying statures, the DuBois formula and other western formulas adequately predicted the measured surface area and DuBois formula was finally recommended as the standard. The Fujimoto formula for adults is one of the most commonly used BSA formulas in Japan [2]. Cancer being a man-made fuelled by the excess of modern life as revealed by a study of ancient remains [13] requires a radical therapeutic approach that put into consideration the use of body surface area that would give moderate effective doses of anti-cancer agents.

Materials and Methods

A total of 319 patients were presented to the Department of...
Haematology, Usman Danfodiyo University Teaching Hospital, Sokoto, Nigeria between January 2008 and December 2013. Patients with diagnosed cases of chronic myeloleukaemia, Non-Hodgkin lymphoma, chronic lymphocytic leukaemia, chronic myeloid lymphoma, Hodgkin disease, chronic myeloid leukaemia, chronic lymphoma, chronic lymphocytic leukaemia, acute leukaemia, Kaposis’s sarcoma, chronic leukaemia lymphoma and chronic myeloid lymphoma were separated from other cases. The commonly used drugs for the treatment of the reported cases are cyclophosphamide, daunorubicin, vincristine, Adriamycin and chlorambucil. The formulas used to determine the constant (i.e. 1.48 = KxH0.725 x W0.425) where constant (K) is equal to 2.008. In essence our formula was developed using Monstellar and Wang et al., Takashira, Fujimoto and Schlich et al. [7,8,10-16] and this paper are DuBois, Boyd, Gehan and George, Haycock et al., Monstellar, Wang et al., Monstellar and Wang et al. and our mean (this paper). Haycock et al. scored 14 (14.1%) with patients serial numbers 3 and 11 having same BSAs also with Monstellar, DuBois, Wang et al. and our mean. Gehan and George and Body formulas scored 13 each whereas Takashira and Fujimoto scored 4 and 3 respectively. Schlich formula scored 2 (2.0%). The BSA values using Schlich formula for the patients serial number 1(2.03), 2(1.91), 3(1.38), 4(1.23), 5(1.33), 6(1.27), 7(1.07), 8(1.08), 9(1.03), 10(1.02) and 11(1.29) respectively are significantly lower (P<0.05) than values obtained by other formulas. The BSA values for patient serial number 1 are same using Monstellar and Wang et al. Schlich formula recorded lowest values of BSA whereas Fujimoto recorded relatively lower BSA values. But Takashira relatively recorded high BSA values. But the mean BSA values of all the patients as obtained from Monstellar, DuBois, Haycock

| S/No | Author | Year of publication | No. of Patients | Formula |
|------|--------|---------------------|----------------|---------|
| 1    | Monstellar [10] | 1987 | Modified Gehan and George | (H x W)/36001/2 |
| 2    | DuBois [7] | 1991 | | 2.024 x 10^1 x H^0.725 x W^0.425 |
| 3    | Haycock et al. [8] | 1978 | 81 | 2.4265 x 10^1 x H^0.824 x W^0.666 |
| 4    | Gehan and George [11] | 1970 | 1907 | 2.35 x 10^1 x H^1.424 x W^1.856 |
| 5    | Boyd [14] | 1935 | | 3.207 x 10^1 x H^0.83 x W^0.326 |
| 6    | Wang et al. [12] | 1992 | Modified DuBois | 7.184 x 10^1 x H^0.726 x W^0.425 |
| 7    | Takashira [15] | 1925 | Unknown | 7.241 x 10^1 x H^0.726 x W^0.425 |
| 8    | Fujimoto [15] | 1968 | 201 | 8.838 x 10^1 x H^0.860 x W^0.444 |
| 9    | Saganuwan and Ndakotsu [unpublished] | | 2008 | 2.008 x 10^1 x H^0.726 x W^0.425 |

**Table 1:** Body surface area formulas.

| S/No | Sex | Age | Body weight (kg) | Height (m) | Body Mass Index | Body Surface Area | Monstaller [10] | DuBois and DuBois [7] | Gehan and George [11] | Haycock et al. [8] | Takashira [15] | Fujimoto [15] | Mean (l) |
|------|-----|-----|-----------------|------------|-----------------|-------------------|-----------------|---------------------|---------------------|-----------------|---------------|--------------|----------|
| 1    | M   | 70  | 78              | 1.9        | 21.61           | 2.05                 | 2.12                 | 2.02                 | 2.03                 | 2.01             | 2.05          | 2.07         | 1.99      |
| 2    | F   | 21  | 72              | 1.85       | 21.04           | 1.92                 | 1.95                 | 1.92                 | 1.93                 | 1.91             | 1.95          | 1.96         | 1.89      |
| 3    | F   | 37  | 51.3            | 1.58       | 20.55           | 1.52                 | 1.50                 | 1.50                 | 1.51                 | 1.51             | 1.50          | 1.52         | 1.46      |
| 4    | M   | 44  | 48.0            | 1.48       | 21.91           | 1.40                 | 1.39                 | 1.41                 | 1.42                 | 1.43             | 1.39          | 1.41        | 1.36      |
| 5    | F   | 45  | 46.5            | 1.59       | 18.39           | 1.43                 | 1.45                 | 1.43                 | 1.44                 | 1.44             | 1.45          | 1.46        | 1.41      |
| 6    | M   | 14  | 48.4            | 1.55       | 18.65           | 1.39                 | 1.40                 | 1.38                 | 1.40                 | 1.40             | 1.40          | 1.41        | 1.36      |
| 7    | F   | 14  | 44.0            | 1.63       | 21.56           | 1.44                 | 1.44                 | 1.40                 | 1.42                 | 1.40             | 1.44          | 1.45        | 1.40      |
| 8    | M   | 15  | 35.5            | 1.46       | 16.65           | 1.20                 | 1.21                 | 1.19                 | 1.21                 | 1.20             | 1.21          | 1.22        | 1.12      |
| 9    | M   | 12  | 31.4            | 1.46       | 14.73           | 1.27                 | 1.15                 | 1.12                 | 1.14                 | 1.13             | 1.15          | 1.16        | 1.12      |
| 10   | F   | 20  | 43.0            | 1.58       | 17.22           | 1.37                 | 1.40                 | 1.36                 | 1.38                 | 1.37             | 1.40          | 1.41        | 1.35      |
| 11   | F   | 14  | 48.0            | 1.53       | 20.50           | 1.43                 | 1.43                 | 1.43                 | 1.44                 | 1.44             | 1.43          | 1.39        | 1.43      |

**Table 2:** The Scoring of body surface area (BSA) formulas for calculation of doses of anticancer agents.

**Keys:** * = Underweight, - = Not applicable

Results
Thirty three (10.3%) out of 319 patients presented to the hospital were diagnosed of white blood cells cancers. Five out of the eleven selected from the 33 patients recorded low body mass index whereas the remaining six recorded normal body weight (Table 2). The results obtained from the use of BSA formula adopted by Wang et al. for all the eleven patients were same with the results obtained by other formulas giving Wang et al. a total score of 21(21.2%). All the results obtained for patients serial numbers 2 – 11 using Wang et al. are same and correlated with those obtained by DuBois which scored 20 (20.2%). However the Monstellar scored (18.2%) with patients serial numbers 2 and 11 having same values of BSA from DuBois, Haycock et al, Wang et al. and our mean (this paper). Haycock et al. scored 14 (14.1%) with patients serial numbers 3 and 11 having same BSAs also with Monstellar, DuBois, Wang et al. and our mean. Gehan and George and Body formulas scored 13 each whereas Takashira and Fujimoto scored 4 and 3 respectively. Schlich formula scored 2 (2.0%). The BSA values using Schlich formula for the patients serial number 1(2.03), 2(1.91), 3(1.38), 4(1.23), 5(1.33), 6(1.27), 7(1.07), 8(1.08), 9(1.03), 10(1.02) and 11(1.29) respectively are significantly lower (P<0.05) than values obtained by other formulas. The BSA values for patient serial number 1 are same using Monstaller and Wang et al. Schlich formula recorded lowest values of BSA whereas Fujimoto recorded relatively lower BSA values. But Takashira relatively recorded high BSA values. But the mean BSA values of all the patients as obtained from Monstaller, DuBois, Haycock

**Table 2:** The Scoring of body surface area (BSA) formulas for calculation of doses of anticancer agents.

**Citation:** Saganuwan SA, Ndakotsu AM (2015) Standardization and Scoring of the Body Surface Area (BSA) Formulas for Calculation of the Doses of Anticancer Agents for Cancer Patients from the North-Western Nigeria. J Cancer Sci Ther 7: 012-018. doi:10.4172/1948-5956.1000319
et al., Ghan and George, Boyd, Wang et al., Takashira and Fujimoto didn’t differ significantly in comparison with our mean. Because of poorest performance of Schlich formula, it was not compared with the rest of the formulas (Table 2).

Tables 3-7 show the calculated doses of cyclophosphamide, daunorubicin, vincristine, doxorubicin and chlorambucil to be increased using Takashira formula and decreased using Fujimoto formula. The formulas of Haycock, Ghan and George provided moderate average BSA for calculated doses of the anticancer agents (Tables 3-7). However, Wang et al. produced the most moderate doses of the anticancer agents (Tables 3-7).

**Discussion**

The fact that 10.3% of the reported cases have white blood cells cancer means that cancer constitutes a significant problem among the people from the North Western Nigeria. The weights of eleven patients whose BSAs were calculated are either underweight or normal weight. So the cancer cases recorded among the patients may not be all attributable to overweight. The relative risks associated with excess weight vary. But generally, there is a strong connection between excess weight and cancer risk for a large number of tumor types [18]. There is a moderate positive association between processed meat consumption and mortality in particular due to cardiovascular diseases, and some forms of cancers [19]. In addition, cell proliferation, cell volume and or biomarkers of protein synthesis may predict response to drugs targeting cancer metabolism [20]. The fact that Wang et al. [12] had the highest score of the correlation of BSA values agrees with the report of Miller [1] indicating that body surface area correlates with basal metabolic rate and is proportional to blood volume. BSA is neither correlated with glomerular filtration rate nor associated with liver function [21,22]. Freireich et al. quantitatively compared toxicity of anticancer agents in mouse, rat, hamster, dog, monkey, and humans and discovered that it correlates very well with body surface area [23].

But the values of BSAs obtained from Dubois [7] are highly correlated with that of Wang et al. [12] suggesting interrelationship of the two formulas. But since the heights of the patients’ serial numbers
the three, Monstellar may be the best. But the fact that Fujimoto scored 1.49 ± 0.08 and may be good for calculation of anticancer agents. Out of and obese patients and to underestimate it for tall and thin patients. But Monstellar formulas have a tendency to overestimate the BSA of short Fujimoto formula, the Boyd, Gehan and George, Haycock et al. and for underestimation of anticancer agents (Tables 2-7). Compared to the 1.47 ± 0.08 and for Boyd is 1.48 ± 0.007 which may likely have tendency with the report of Kouno et al. [2] indicating that the anticancer agents to under-dose of the anticancer agents. Our finding is in agreement Therefore, using Fujimoto formula to dose the 33 patients may lead in similar BSA products [16]. However, compared with the other western formulas and the Takashira formula calculations resulted height was 170 cm and the body mass index was 22 kg/m², the five Monstellar recorded many similar results. For a typical case where the...
This should serve as a challenge to find alternative dosing strategies for anticancer agents [1]. Indices of body measures are numerous for both humans and animals. Investigators used three approaches in measuring body weight because it is less affected by abnormal adipose mass. But many hurdles will be probably had to be overcome before physicians will be willing to ban BSA dosing [38].

However, in the majority of investigational new drug applications, animal data are not available in sufficient detail to construct a scientifically valid, pharmacokinetic model whose aim is to accurately project the maximum recommended starting dose (MRSD) for first-in-human clinical trials of new molecular entities [39]. For many clinical purposes BSA is a better indicator of metabolic mass than body weight because it is less affected by abnormal adipose mass. But determining anticancer agents with a narrow therapeutic index using BSA may have long height. There was an average BSA of 1.73 m² for cancer patients from Europe [44]. BSA of 1.79 m² for adult patients in the UK, among them the average BSA for men was 1.91 m² and for women was 1.71 m². However, average BSA for neonate (0.25 m²), child of 2 years (0.5 m²), 9 years (1.07 m²), 10 years (1.14 m²), 12 – 13 years (1.33 m²), women (1.6 m²) and men (1.9 m²) have also been reported [45]. Excess weight is a clear risk factor for a number of cancers that are becoming prevalent in industrialized parts of the world. Aggressive prostate cancer risks are clearly increased in men that are in the overweight or obese categories [17].

A daily oral dose of cyclophosphamide 100 mg/m² for 14 days has been recommended for patients with lymphomas and chronic lymphocytic leukaemia. The recommended intravenous dose of daunorubicin is 30 to 60 mg/m² daily for 3 days in treatment of Kaposis sarcoma. Adult patients with Hodgkin’s disease or non-Hodgkin’s lymphoma usually receive 1.4 mg/m² of Vincristin which seems to be tolerated better by children than by adults. The recommended dose of intravenous Doxorubicin (Adriamycin) is 50 to 75 mg/m² administered as a single rapid intravenous infusion that is repeated after 21 days. It is effective against malignant lymphomas. Chlorambucil is a standard agent for patient with chronic lymphocytic leukaemia at 0.1 to 0.2 µg/kg, given once daily and continued for 3 to 6 weeks [46]. Although, the Monsteller formula was adopted for use by the pharmacy and therapeutics of Cross Cancer Institute, Edmonton Alberta, Canada [47]. Reilly and Workman [48] and Gurney [21] suggested that the routine use of body surface area for dose calculation should be re-evaluated and that other methods of dose calculation should be investigated. Baker et al. have pondered scientific evidence that body surface area-based dosing has very limited utility [35].

**Conclusion**

BSA based dosing has failed to standardize the variation in PK for most anticancer agents, and individual dosing techniques are currently being investigated. However their utilities need to be confirmed and so
it is necessary to depend on the BSA-based calculation for determining the dose of most anticancer agents. But Wang et al. has been discovered to be the most suitable for white blood cells cancer patients from the North-Western Nigeria. It provides moderate doses of anticancer agents that may neither cause increased toxicity signs nor high risk of cancer remission.

Competing Interest

There is no competing interest, whatsoever between the authors and any other person, organization and Usmanu Danfodiyo University Teaching Hospital Sokoto, Nigeria.

Funding

This work was done using our monthly salaries.

Author’s contributions

Dr. S.A. Saganuwan collated and analysed the data. He also prepared—proof-read the manuscript. Dr. A.M. Ndakotsu is a consultant who attended to the patients. He diagnosed and treated the patients using different anticancer agents. He also proof-read the manuscript.

References

1. Miller AA (2002) Body surface area in dosing anticancer agents: scratch the surface! J Natl Cancer Inst 94: 1822-1823.

2. Kouno T, Katsumata N, Mukai H, Ando M, Watanabe T (2003) Standardization of the body surface area (BSA) formula to calculate the dose of anticancer agents in Japan. Jpn J Clin Oncol 33: 309-313.

3. Camro-Pereira J, Costa FO, Henriques E, Godinho F, Cantinho-Lopes MG, et al. (1987) A comparison of two doses of Adriamycin in the primary chemotherapy of disseminated breast carcinoma. Br J Cancer 56: 471-473.

4. Wood WC, Budman DR, Korzun AH, Cooper MR, Younger J, et al. (1994) Dose and dose intensity of adjuvant chemotherapy for stage II, node-positive breast carcinoma. N Engl J Med 330: 1253-1259.

5. Samson MK, Pivkin SE, Jones SE, Costanzi JJ, LoBuglio AF, et al. (1994) Dose-response and dose-survival advantage for high versus low doses cisplatin combined with vincristine and bleomycin in disseminated testicular cancer: A south-west oncology group study. Cancer 53: 1029-1035.

6. Gunery HP, Ackland S, Gebski V, Farrell G (1998) Factors affecting epirubicin pharmacokinetics and toxicity: evidence against using body-surface area for dose calculation. J Clin Oncol 16: 2299-2304.

7. DuBois D, DuBois EF (1916) A formula to estimate the approximate surface area of height and weight be known. Archive of Internal Medicine 17: 863-871.

8. Haycock GB, Schwartz GJ, Wisotsky DH (1978) Geometric method for measuring body surface area: a height-weight formula validated in infants, children, and adults. J Pediatr 93: 62-66.

9. Martin AD, Drinkwater DT, Clarys JP (1984) Human body surface area: validation of formulae based on a cadaver study. Hum Biol 56: 475-488.

10. Mosteller RD (1987) Simplified calculation of body-surface area. N Engl J Med 317: 1098.

11. Gehan EA, George SL (1970) Estimation of human body surface area from height and weight. Cancer Chemother Rep 54: 225-235.

12. Wang Y, Moss J, Thisted R (1992) Predictors of body surface area. J Clin Anesth 4: 4-10.

13. Macrae F (2010) Cancer is purely man-made say scientists after finding almost no trace disease in Egyptian mummies. Mail Online.

14. Boyd E (1935) The growth of the surface area of the human body. University of Minnesota Press, Minneapolis.

15. Fujimoto S, Watanabe T, Sakamoto A, Yukawa K, Morimoto K (1968) [Studies on the physical surface area of Japanese. 18. Calculation formulas in three stages over all ages]. Nihon Eiseigaku Zassi 23: 443-450.

16. Schlich E, Schummm M, Schlich M (2010) 3 – D – Body scan also anthropometrisches Verfahren zur Bestimmung der spezifischen Körperoberfläche. Emnahruno Umschau 57: 178-183.

17. Howel DG (2003) Fundamental Statistics for the Behavioural Science, 5th edition, Thomson Wadsworth, Belmont, USA pp 570.

18. Kaaks R (2013) Video Q&A: excess body weight and cancer. BMC Med 11: 2.

19. Rohmann S, Overvad K, Bueno-de-Mesquita HB, Jakobsen MU, Egeberg R, et al. (2013) Meat consumption and mortality—results from the European Prospective Investigation into Cancer and Nutrition. BMC Med 11: 63.

20. Dolfi SC, Chan LL, Qiu J, Tedeschi PM, Bertino JR, et al. (2013) The metabolic demands of cancer cells are coupled to their size and protein synthesis rates. Cancer Metab 1: 20.

21. Dooley MJ, Poole SG (2000) Poor correlation between body surface area and glomerular filtration rate. Cancer Chemother Pharmacol 46: 523-526.

22. Gurney H (1996) Dose calculation of anticancer drugs: a review of the current practice and introduction of an alternative. J Clin Oncol 14: 2590-2611.

23. Freireich EJ, Gehan EA, Rall DP, Schmidt LH, Skipper HE (1966) Quantitative comparison of toxicity of anticancer agents in mouse, rat, hamster, dog, monkey, and man. Cancer Chemother Rep 50: 219-244.

24. Meeh K (1879) Oberflächenmessungen des menschlichen körpers. Ztschr Biol 15: 425 – 458.

25. Pinkel D (1998) Cancer chemotherapy and body surface area. J Clin Oncol 16: 3714-3715.

26. Pinkel D (1958) The use of body surface area as a criterion of drug dosage in cancer chemotherapy. Cancer Res 18: 853-856.

27. Grochow LB, Baraldi C, Noe D (1990) Is dose normalization to weight or body surface area useful in adults? J Natl Cancer Inst 82: 323-325.

28. Ratain MJ (1998) Body-surface area as a basis for dosing of anticancer agents: science, myth, or habit? J Clin Oncol 16: 2297-2298.

29. Kunihit H, Watanabe K (1994) Phase I/II and pharmacologic study of long-term continuous infusion etoposide combined with cisplatin in patients with advanced non-small-cell lung cancer. J Clin Oncol 12: 83-89.

30. Madden T, Sunderland M, Santana VM, Rodman JH (1992) The pharmacokinetics of high-dose carboplatin in pediatric patients with cancer. Clin Pharmacol Ther 51: 701-707.

31. de Jongh FE, Verweij J, Loos WJ, de Wit R, de Jonge MJ, et al. (2001) Body-surface area-based dosing does not increase accuracy of predicting cisplatin exposure. J Clin Oncol 19: 3733-3739.

32. Moore MJ, Erlichman C, Thiessen JJ, Bunting PS, Hardy R, et al. (1994) Variability in the pharmacokinetics of cyclophosphamide, methotrexate and 5-fluorouracil in women receiving adjuvant treatment for breast cancer. Cancer Chemother Pharmacol 33: 472-476.

33. Launay-Liadas MC, Bruno R, Cosson V, Vergniol JC, Quild-Aissa D, et al. (1995) Population pharmacokinetics of docetaxel during phase I studies using non-linear mixed-effect modelling and non-parametric maximum-likelihood estimation. Cancer Chemother Pharmacol 37: 47-54.

34. Wang J, Hihara E (2004) A unified formula for calculating body surface area of humans and animals. Eur J Appl Physiol 92: 13-17.

35. Baker SD, Verweij J, Rowinsky EK, Donohower RC, Schellens JH, et al. (2002) Role of body surface area in dosing of investigational anticancer agents in adults, 1991-2001. J Natl Cancer Inst 94: 1883-1888.

36. USEPA (2002) Recommend Use of Body Weight3/4 as the Default method in Derivation of the Oral Reference Dose. United States Environmental Protection Agency Washington, DC 20460, EPA/100/R11/0001 Final. 2002, 1 – 39.

37. Kleber M (1947) Body size and metabolic rate. Physiol Rev 27: 511-541.

38. Mathijssen RH, de Jong FA, Loos WJ, van der Bol JM, Verweij J, et al. (2007) Prospective Investigation into Cancer and Nutrition. BMC Med 11: 63.

39. Hettinger EH, Bataille V, Burkhart BL, et al. (1997) Anthropometric and demographic data from the chemical and companionate risk analysis database. United States Department of Health and Human Services, Food and Drug Administration, Center for Drug Evaluation and Research (CDER), Pharmacology and Toxicology: 1-27.
40. Gao B, Klumpen HJ, Gurney H (2008) Dose calculation of anticancer drugs. Expert Opin Drug Metab Toxicol 4: 1307-1319.

41. Gurney H (2002) How to calculate the dose of chemotherapy. Br J Cancer 86: 1297-1302.

42. Costeff H (1966) A simple empirical formula for calculating approximate surface area in children. Arch Dis Child 41: 681-683.

43. Furqan M, Haque A (2009) Surface area in children: a simple formula. Indian Pediatr 46: 1085-1087.

44. Sparreboom A, Verweij J (2003) Paclitaxel pharmacokinetics, threshold models, and dosing strategies. J Clin Oncol 21: 2803-2804.

45. Sacco JJ, Botten J, Macbeth F, Bagust A, Clark P (2010) The average body surface area of adult cancer patients in the UK: a multicentre retrospective study. PLoS One 5: e9333.

46. Brunton LL, Lazo JS, Parker KL (2006) Goodman and Gilman’s, The Pharmacological Basis of Therapeutics, 11th ed., McGraw – Hill Medical Publishing Division, USA: 2021.

47. Lam TK, Leung DT (1988) More on simplified calculation of body-surface area. N Engl J Med 318: 1130.

48. Reilly JJ, Workman P (1993) Normalisation of anti-cancer drug dosage using body weight and surface area: is it worthwhile? A review of theoretical and practical considerations. Cancer Chemother Pharmacol 32: 411-418.