# Radiation-induced skin pigmentation after accelerated partial breast irradiation: dose-volume histogram analysis

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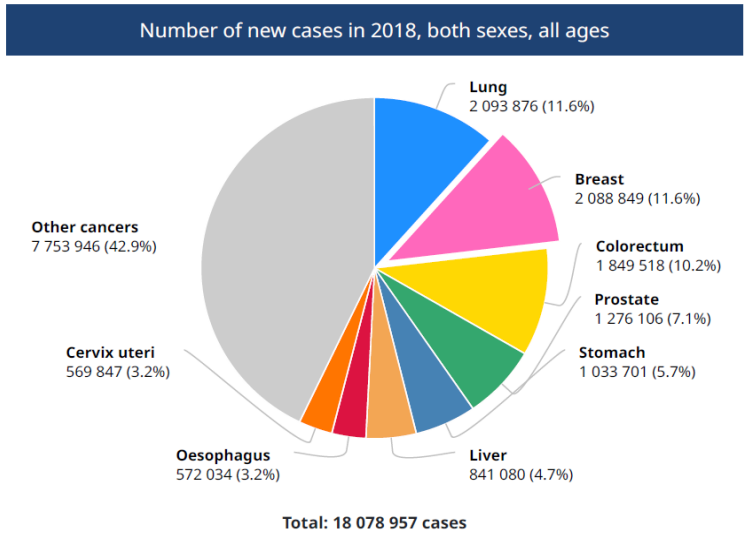
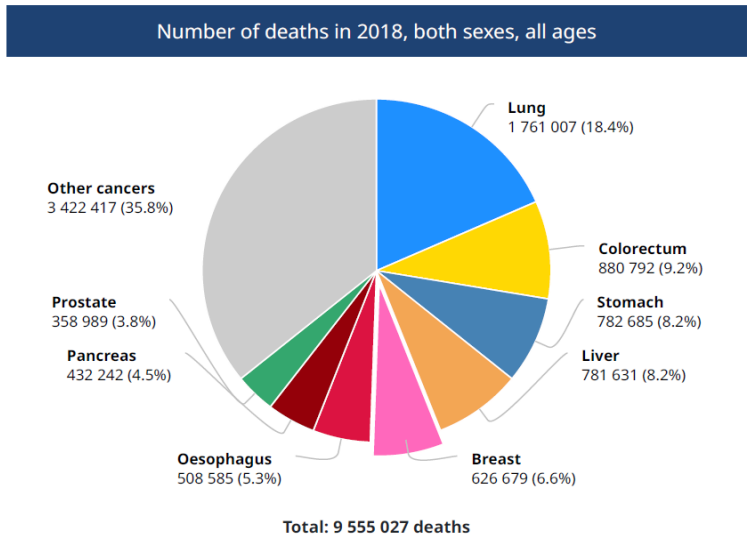
# Problem definition

Breast cancer (BC) is the most common malignant disease among women all over the world. The last observations show a tendency to age decreasing of patients with this diagnosis. Therefore, organ-preserving methods of treatment are becoming more and more relevant.




Number of new cases of breast cancer and deaths from this malignancy in 2018 according to the world health organisation

# Problem definition

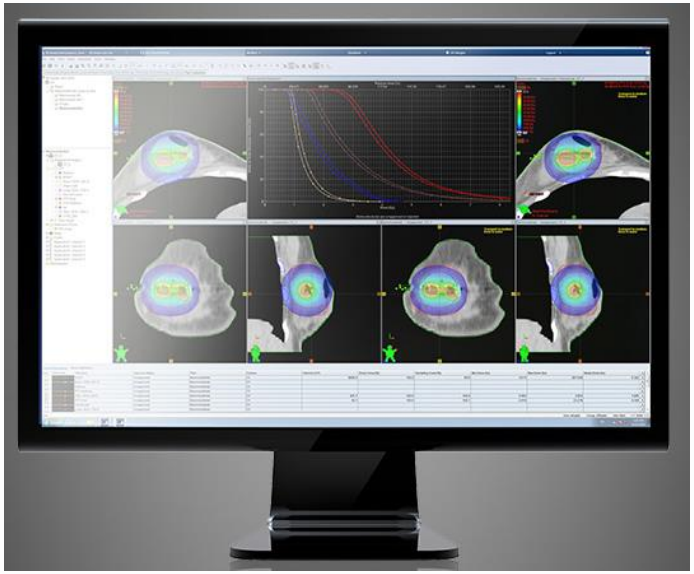
Lumpectomy with the subsequent brachytherapy is the most promising treatment of this disease in the early stages. One of the main goals during the development of the method is to assess the biological radiation tolerance to the organs-at-risk (OARs), which include skin, ribs, lungs, heart and liver.

This study reports about 7 cases of radiation-induced skin pigmentation after APBI based on the analysis of the dose-volume histograms (DVHs) of 28 patients.

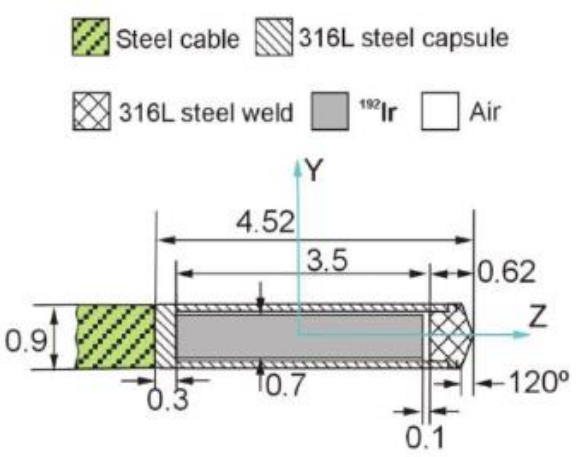
# Materials and Methods

This research demonstrates the treatment of breast cancer with high dose rate (HDR) brachytherapy in the mode 34 Gy in 10 twice-daily treatments, six hours apart, and over five days. According to this protocol, the maximum allowable radiation exposure for the skin does not exceed 34 Gy. By May 2019, 28 patients were treated with a mean follow-up 10.5 months, the median of the study is 11 months.

A device for HDR brachytherapy GammaMedplus

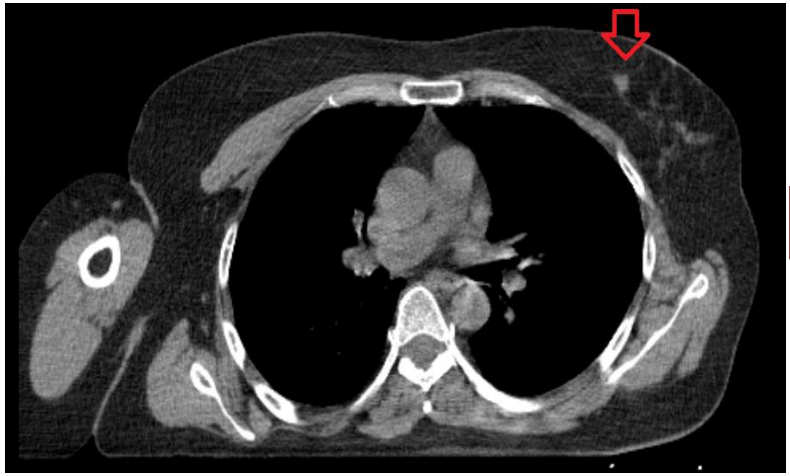


BrachyVision treatment planning system



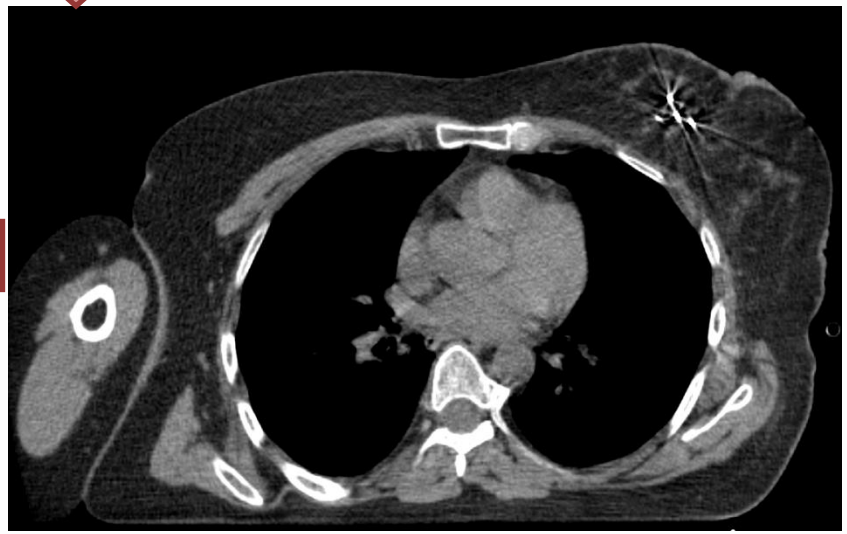

$^{192}$Ir source model

# The scheme of HDR brachytherapy

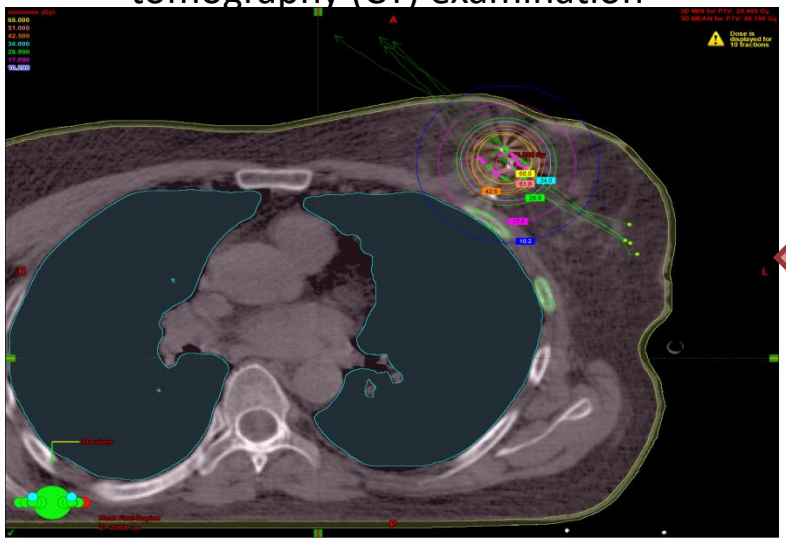


I – preoperative diagnostic computed tomography (CT) examination

II – lumpectomy + lymph node dissection



III – postoperative CT examination

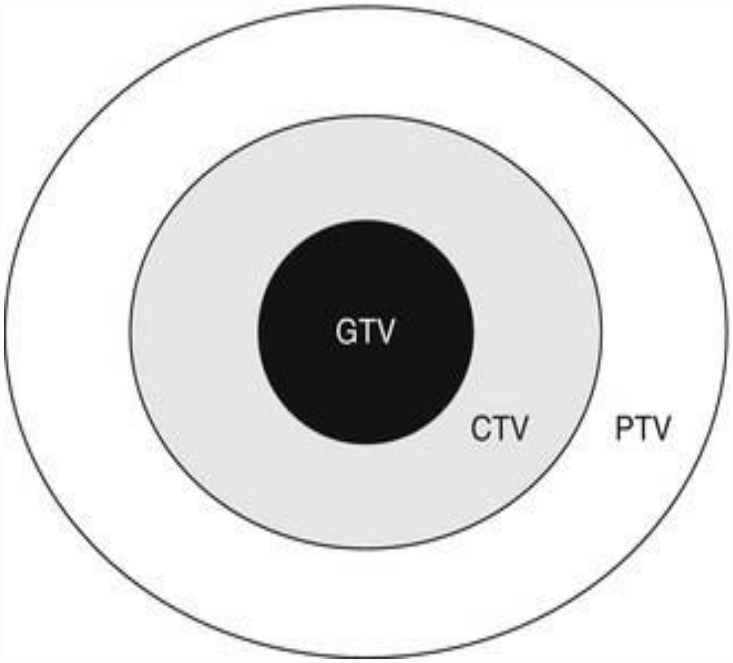


IV – treatment planning

# Optimal criteria and tolerant doses

| PTV and OARs | Constraints |
|---|---|
| $V_{90\,,\,\%}$ | ≥ 90 % absolute PTV volume |
| Skin | $D_{max}$≤ 100% from prescribed dose |
| Ribs | $D_{max}$≤ 145% from prescribed dose |
| Lung | $D_{max}$≤ 60% from prescribed dose |
| | $D_{mean}$≤ 8% from prescribed dose |
| Heart | $D_{max}$≤ 50% from prescribed dose |
| | $D_{mean}$≤ 8% from prescribed dose |
| Liver | $D_{max}$≤ 60% from prescribed dose |

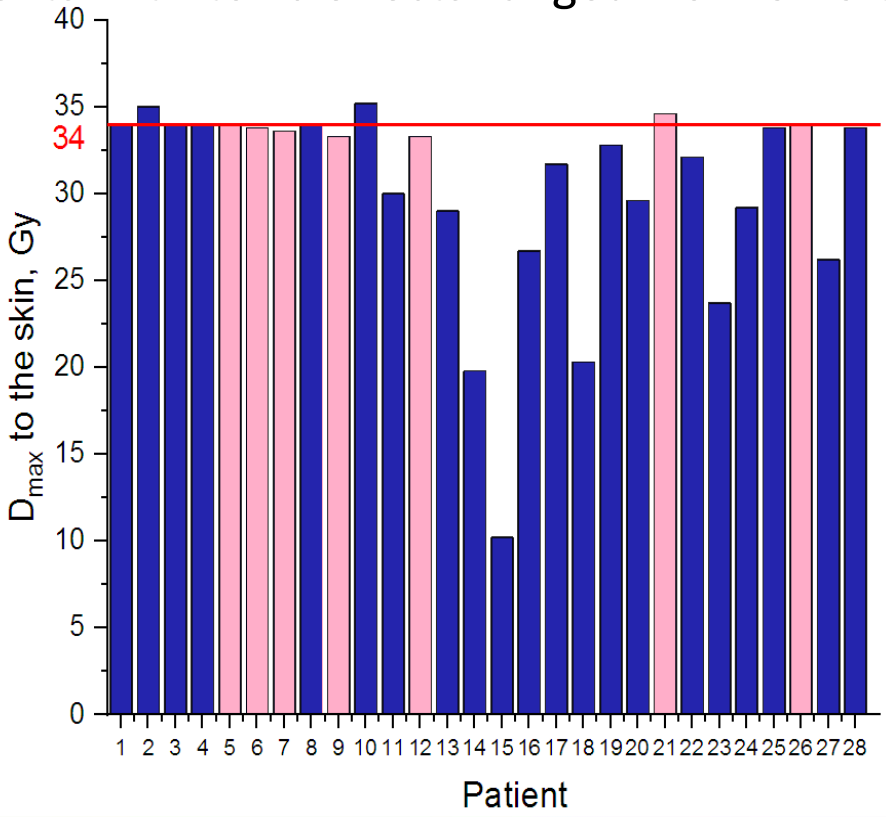
Recommended dose-volume constraints for target volume and OARs




The scheme of the target contouring

# $D_{max}$ values to the skin for all patients

The fact that only 1 of them had pigmentation is of interest. At the same time, another 6 patients 5-7, 9, 12 and 26 (highlighted in pink), whose $D_{max}$ was lower or equal to the permissible maximum of radiation exposure showed toxic effects. The patient 10 has the maximal excess of the skin dose, and it was 1.2 Gy. The values of patients with toxic effects ranged from 34.6 to 33.3 Gy (33.8 ± 0.42 Gy averaged).



# *Values of the volumetric dosimetric parameters to the skin for patients with toxic effexts*

Mean $D_{0.01cc}$ to the skin is 32.34 ± 0.77 Gy and its $EQD_2$ is equal to 40.2 Gy. At the same time, $D_{0.1cc}$ = 30.60 ± 0.99 Gy ($EQD_2$ = 37.1 Gy); $D_{1cc}$ = 26.71 ± 1.61 Gy ($EQD_2$ = 30.3) and $D_{0.1cc}$ = 24.24 ± 2.24 Gy ($EQD_2$ = 23.5).

| Patient | $D_{0.01cc}$, Gy | $D_{0.1cc}$, Gy | $D_{1cc}$, Gy | $D_{2cc}$, Gy |
|---|---|---|---|---|
| 5 | 33 | 31 | 27 | 24 |
| 6 | 31 | 29 | 24 | 20 |
| 7 | 32 | 30 | 27 | 25 |
| 9 | 32 | 30.4 | 27 | 24 |
| 12 | 32 | 30 | 26 | 23 |
| 21 | 33.4 | 31.8 | 29 | 27.7 |
| 26 | 33 | 32 | 27 | 26 |

# *Values of the volumetric dosimetric parameters to the skin for 2 patients with the dose excess on the $D_{max}$ parameter*

Two patients with the dose excess (2, 10) on the $D_{max}$ parameter were estimated separately.

It can be noted that when the maximum dose limit was exceeded, one of the patients had a lower value of volumetric doses compared with those who had pigmentation. The second patient had approximately equal measurements on the $D_{0.01cc}$ and $D_{0.1cc}$ parameters. However, the other 2 ($D_{1cc}$ and $D_{2cc}$) were at a sufficiently low level.

| Patient | $D_{0.01cc}$, Gy | $D_{0.1cc}$, Gy | $D_{1cc}$, Gy | $D_{2cc}$, Gy |
|---|---|---|---|---|
| 2 | 28 | 22 | 16 | 15 |
| 10 | 34 | 32 | 27 | 25 |

# Conclusion

- The expected effects, as well as the results of treatment, are very individual and depend on many factors.

- Based on our results, it appears that in the area of the maximal permissible doses we should assess as the maximal setting as volumetric to predict toxic effects. So, it is necessary to be careful with the values of $D_{max} \geq 33$ Gy, $D_{0.01cc} \geq 32$, $D_{0.1cc} \geq 30$, $D_{1cc} \geq 27$ and $D_{2cc} \geq 24$.

- Nevertheless, given the limited number of patients of the investigation and the short follow-up period, the study should be continued, and in the future, perhaps, the selection criteria and radiation exposure restrictions should be reviewed.

# Thanks for your attention!