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## **Exposure of the lungs in breast cancer radiotherapy: A systematic review of lung doses published 2010-2015**

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**Purpose:** Radiotherapy for breast cancer improves mortality but may cause lung cancer. We report a systematic review of lung doses from breast cancer dosimetry studies.

**Methods and Materials:** Eligible studies were published during 2010-2015 and reported lung dose from breast cancer radiotherapy. Analyses considered the arithmetic mean of the doses from the CT plans used in each regimen. They focused on the mean dose and V20<sub>Gy</sub> (volume of lung receiving  $\geq 20$ Gy) to the ipsilateral lung and on mean dose to the contralateral lung

**Results:** 144 studies from 28 countries reported mean ipsilateral lung dose (MLD<sub>ipsi</sub>) from 481 regimens. MLD<sub>ipsi</sub> averaged over these regimens was 8.9 Gy (IQR 5.5-12.5 Gy).

For a given regimen (tangential irradiation of the breast or chest wall in the supine position and without breathing adaptation) there was considerable variation in MLD<sub>ipsi</sub> between different countries. In 119 regimens from 72 studies and 27 countries, the average MLD<sub>ipsi</sub> in each country varied from 0.4 Gy (Canada) to 13.5 Gy (Spain).

For whole breast or chest wall radiotherapy (in the supine position and without breathing adaptation) the average MLD<sub>ipsi</sub> was 8.4 Gy (IQR 5.9-11 Gy) from 241 regimens. When the axilla or supraclavicular fossa was also included, the average MLD<sub>ipsi</sub> increased to 11.7 Gy (IQR 9.0-14.3). The addition of the internal mammary chain increased it further to 13.6 Gy (IQR 10.0-18.0 Gy).

Comparing different techniques for irradiation of the whole breast or chest wall, breathing adaptation reduced MLD<sub>ipsi</sub> from 8.4 (241 regimens with no breathing adaption) to 6.3 Gy (20 regimens with breathing adaption). Treatment in alternative positions reduced MLD<sub>ipsi</sub> to 1.6 Gy (prone, based on 17 regimens) and 0.9 Gy (lateral decubitus, based on 2 regimens). The highest MLD<sub>ipsi</sub> were reported for intensity modulated radiotherapy, 9.1 Gy, based on 74 regimens and volumetric modulated arc therapy, 9.9 Gy, based on 42 regimens. Similar dose differences between techniques were observed for V20<sub>Gy</sub>.

60 studies reported mean contralateral lung dose (MLD<sub>cont</sub>) in 221 regimens. The average MLD<sub>cont</sub> was 2.4 Gy (IQR 0.4-3.8 Gy). For treatment of the whole breast or chest wall in the supine position, tangential radiotherapy delivered average MLD<sub>cont</sub> 0.7 Gy (IQR 0.2-0.6). The highest MLD<sub>cont</sub> were received from 3D conformal rotational therapy (4.6 Gy), IMRT (3.1Gy) and VMAT (2.9 Gy).

## Conclusion

Lung doses from breast cancer radiotherapy vary substantially worldwide, even between studies describing apparently similar regimens. Inclusion of the regional lymph nodes considerably increased the  $MLD_{ipsi}$  relative to irradiation of the whole breast only. IMRT and VMAT regimens tended to deliver higher  $MLD_{cont}$  than other regimens.