COLUMNS

This technologically advanced method of radiotherapy delivery can destroy cancer with painless and precise radiation beams.

by Dr. David Tan

The lightsaber of radiation therapy

A long time ago in a galaxy far, far away

In the Star Wars legend, the lightsaber is an iconic weapon used by the Jedi, who are guardians of peace in the Galactic empire. According to Wookiepaedia, a Star Wars fan site, lightsabers, also referred to as laser swords, are powered by a unique kyber crystal at its core that emits a plasma beam, usually from a metal hilt, that can be shut off at will. It is a weapon that requires skill and training, and can cut through virtually anything, from enemies to blast doors with great precision. Jedi Master Obi-Wan Kenobi once described the lightsaber as:

"…the weapon of a Jedi Knight.
Not as clumsy or random as a blaster.
An elegant weapon for a more civilised age."

Stereotactic Ablative Radiotherapy - The LightSABeR of radiation therapy

Stereotactic ABlative Radiotherapy, also known as SABR, is fondly regarded by the oncology community as the lightsaber of radiation therapy.

It is a technologically advanced method of radiotherapy delivery that uses state-of-the-art beam delivery systems coupled with superior targeting techniques to deliver a precise and powerful beam of radiation to deep-seated tumours.

With advanced training and meticulous practice, SABR-trained radiation oncologists can harness this technology to produce a lightsaber-like beam of focused radiation that was impossible to achieve in the past.

The extreme accuracy of SABR treatments allows high doses of radiation to be delivered in one or a few shots to the desired target in the body, producing superior destruction with minimal damage to surrounding organs such as the heart, oesophagus, and spinal cord.

With SABR, an entire treatment course can be completed in three to five sessions over two weeks, compared to conventional radiotherapy treatment which requires up to 35 sessions over seven weeks.

The dark side of lung cancer

Lung cancer is the second and third most common cancer in males and females respectively. It is also the leading cause of cancer death globally. Therefore, even when diagnosed at an early stage, lung cancer is a serious diagnosis requiring prompt and aggressive treatment.

While surgery is traditionally seen as the gold standard for early lung cancer, majority of patients are not fit enough to undergo such a high-risk procedure. Factors such as advanced age, poor lung function from a long smoking history, or chronic illnesses such as diabetes and heart disease are important considerations for such patients.

In the past, patients ineligible for surgery would be offered alternatives such as conventional radiotherapy or chemotherapy. Such treatments however come at a considerable cost of time (7 weeks for radiotherapy and 18 weeks for chemotherapy) and significant toxicity. More importantly, cure rates with such alternatives are poor with only 20 to 30 per cent of patients surviving more than five years.

Conventional radiotherapy - Clumsy or random as a blaster

In the past, conventional radiotherapy was carried out by machines which lacked the technology to produce focused and precise radiation beams. The resultant beam was large

and did not conform to the shape of the tumour, giving rise to a high risk of collateral damage. The large treatment fields also limit the total dose of radiation that could be delivered to the tumour and necessitated that the radiotherapy be administered in low daily doses spread out over six to seven weeks.

While newer machines in the 20th century have improved on the clumsier beams of the older generation with better beam-shaping technology, another challenge remains in the delivery of radiotherapy in lung cancers – the random movement of the tumour as the patient breaths normally during treatment. The most common method to account for this random movement is to expand the "blast zone" up to 2cm around the tumour to ensure the radiation beams will not miss the tumour as it moves. Such method however increases the risk of side effects and again, limits the maximum dose that can be delivered to the actual target.

Because of the above factors, conventional radiotherapy is regarded as a poor alternative to surgery in early lung cancer, resulting in dismal survival rates of only 20 to 30 per cent in five years.

SABR - An elegant weapon for a more civilised age

SABR, however, has changed the landscape of lung cancer treatment since its introduction in the early 2000s. Through the combination of state-of-the-art radiotherapy delivery systems, real time high-resolution CT targeting, and superior tumour immobilisation, SABR has enabled radiation oncologists to overcome the challenges associated with conventional radiotherapy in the following ways:

State-of-the-art radiotherapy machines

Apart from the superior beam shaping capabilities available in all modern radiotherapy machines today, many SABR-ready systems can deliver the precise beam at high dose rates using a technology known as "flattening filter-free" radiotherapy or FFF, allowing doses up to 10 times more conventional radiotherapy doses to be delivered in less than five minutes. These machines also have the ability to fire numerous tiny beams from multiple angles around the patient's body where they then converge precisely at the target, depositing all their energy within the tumour.

Real-time high-resolution tumour targeting

SABR-ready machines also come with in-built CT scanners to perform high resolution verification scans just before the patient starts his treatment. These scans allow the radiation oncologist to verify the position of the target against the initial planning CT scan to ensure sub-millimetre accuracy in treatment delivery. Some machines can even acquire scans which capture the fourth dimension of the target position – the real-time movement of tumour in the body. Such 4D-CT scans record multiple CT images over time, allowing playback of the scans as a video so that the internal movement of the tumour can be mapped out and accurately targeted.

Lung SABeR destroys lung cancer with painless and precise radiation beams

Superior tumour immobilisation techniques

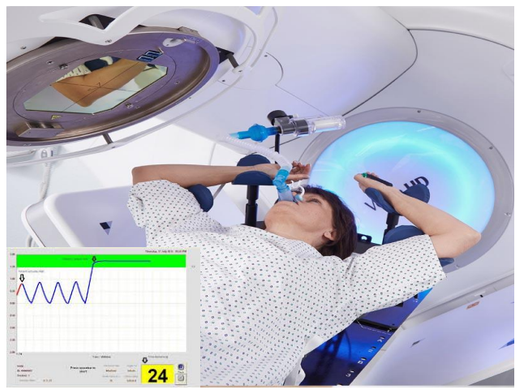
One of the most critical steps in SABR is the immobilisation of the tumour during treatment, also known as "achieving stereotaxis". This minimises the randomness or uncertainty that comes with a moving target and ensures the precise beams hit their target every time.

One technique is the use of a breath-hold device which comprises a scuba-diving like mouthpiece attached to the pressure system that measures the amount of air in a patient's lungs as he or she breathes into the mouthpiece. When the patient has inhaled or exhaled a set amount of air indicating the tumour is fixed at its desired position, the patient holds his breath for 20 to 30 seconds while the machines fires its beams into the "frozen" tumour. Other immobilisation methods include "tumour-tracking", where the machine gantry moves in sync with the tumour as it fires its beams, or "gating", where the static gantry fires only when the moving target falls within certain pre-defined positions in the body.

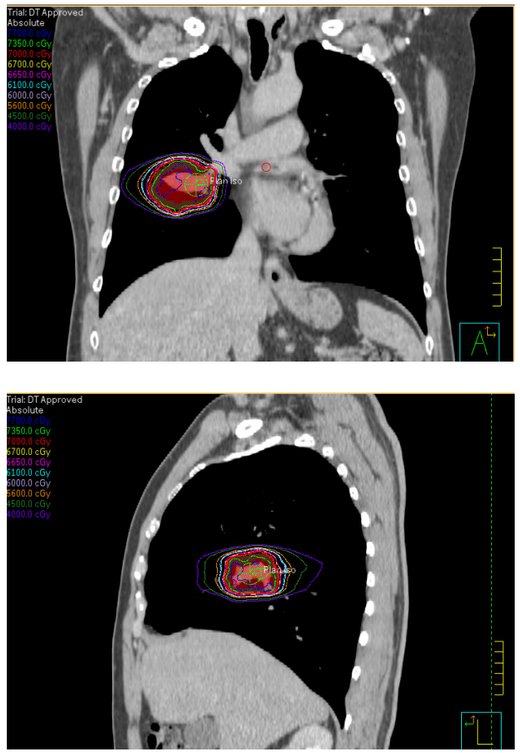
A new hope for lung cancer patients

Studies employing SABR for early lung cancers have shown excellent tumour control and survival rates of 85 per cent at three years. These rates are similar to those achieved in patients who undergo surgery. In addition, side effects, complications and post-treatment death rates are significantly lower in patients undergoing SBRT instead of surgery, especially in the elderly population.

The American Society of Radiation Oncology (ASTRO) has recently published guidelines recommending SABR as an alternative to surgery in patients with high operative risk, and supporting a discussion on SABR in patients with standard operative risk. These guidelines have been endorsed by the corresponding European and Australian Radiotherapy and Oncology Societies, marking a global paradigm shift in lung cancer treatment.



Patient on the treatment couch using the spirometer linked to the treatment machine, that measures real time lung volumes (screen bottom left corner). Treatment is only delivered in a fixed breath hold position as predetermined during the mapping session. Source: www.elekta.com/radiotherapy/treatment-solutions/motion-management/active-breathing-coordinator.html



Stereotactic body radiotherapy plan showing treatment of lung tumour using beams delivered in arcs, concentrating high doses to the tumour while sparing large volumes of normal lung

Patients with early lung cancer now have a new hope for cure in lung SABR. They should consult both a radiation oncologist and thoracic surgeon for discussion on the most appropriate treatment. We are fortunate to live in an era where advanced technology can be harnessed to provide new hope in the fight against cancer. APBN

Dr. David Tan is a consultant radiation oncologist at the Asian American Radiation & Oncology, Singapore.