

CLAIMS:

1. An elution system comprising:
 - a radioisotope generator configured to release a radioactive eluate containing a daughter radioisotope during an elution with an eluant the daughter radioisotope being produced from radioactive decay of a parent radioisotope contained within the radioisotope generator;
 - an eluate tubing line in fluid communication with the radioisotope generator;
 - a radioactivity detector positioned to detect a radioactivity of the radioactive eluate while the radioactive eluate is flowing through the eluate tubing line; and
 - a controller communicatively coupled to the radioactivity detector and configured to:
 - receive data indicative of the radioactivity of the radioactive eluate generated during the elution thereby providing a radioactivity profile of the radioactive eluate relative to at least one of a time during the elution and a volume of radioactive eluate generated during the elution, and
 - determine a characteristic of the radioactivity profile indicative of breakthrough of the parent radioisotope into the radioactive eluate.
2. The system of claim 1, wherein the controller is further configured to compare the determined characteristic of the radioactivity profile indicative of breakthrough to a breakthrough threshold for the characteristic.
3. The system of any one of the foregoing claims, wherein the controller is further configured to determine a remaining capacity of the radioisotope generator before breakthrough.
4. The system of any one of the foregoing claims, wherein the controller is further configured to at least one of (1) issue a user alert and (2) not allow a patient infusion, if the determined characteristic exceeds the breakthrough threshold.
5. The system of claim 4, wherein the controller is further configured to determine a remaining capacity of the radioisotope generator before breakthrough and provide a user alert indicative of the remaining capacity.

6. The system of any one of the foregoing claims, wherein the characteristic of the radioactivity profile indicative of breakthrough of the parent radioisotope into the radioactive eluate comprises a lapsed time or a lapsed volume during the elution between when the radioactivity of the radioactive eluate, or a derivative thereof, is at a first predetermined level and when the radioactivity of the radioactive eluate, or a derivative thereof, is at a second predetermined level.

7. The system of claim 6, wherein the derivative of the radioactivity of the radioactive eluate is a first derivative of the radioactivity of the radioactive eluate over the lapsed time or the lapsed volume, wherein the first predetermined level and the second predetermined level each correspond to a predetermined rate of change of the radioactivity of the radioactive eluate over time or volume.

8. The system of claim 6, wherein the derivative of the radioactivity of the radioactive eluate is a second derivative of the radioactivity of the radioactive eluate over the lapsed time or the lapsed volume, wherein the first predetermined level and the second predetermined level each correspond to a predetermined rate of change of a first derivative of the radioactivity of the radioactive eluate over time or volume.

9. The system of any one of claims 6–8, wherein the first predetermined level is a zero value.

10. The system of any one of the foregoing claims, wherein the characteristic of the radioactivity profile indicative of breakthrough of the parent radioisotope into the radioactive eluate comprises a lapsed time or a lapsed volume during the elution between a start of the elution and when the radioactivity of the radioactive eluate, or a derivative thereof, is at a second predetermined level.

11. The system of claim 10, wherein the second predetermined level is a maximum radioactivity of the radioactive eluate.

12. The system of claim 10, wherein the second predetermined level is about 40% of a maximum radioactivity of the radioactive eluate.

13. The system of any one of the foregoing claims, wherein the radioactivity profile is relative to the time during the elution, the time during elution being a cumulative time from a start of a pump pumping the eluant through the radioisotope generator.
14. The system of any one of the foregoing claims, wherein the radioactivity profile is relative to the volume during the elution, the volume during elution being a cumulative volume from a start of a pump pumping the eluant through the radioisotope generator.
15. The system of any one of the foregoing claims, wherein the controller is configured to issue the user alert by at least controlling a display to issue a visual alert.
16. The system of any one of the foregoing claims, wherein the radioactivity detector comprises a beta detector.
17. The system of any one of the foregoing claims, wherein the radioactivity detector comprises a gamma detector.
18. The system of any one of the foregoing claims, wherein the system mounted on a mobile cart.
19. The system of any one of the foregoing claims, further comprising a base frame with wheels, wherein the radioisotope generator and the radioactivity detector are mounted on the base frame so as to be movable.
20. The system of claim 19, wherein the controller is also mounted to the base frame.
21. The system of claim 19, wherein the controller is remote from base frame and communicatively connected to the radioactivity detector via a network.
22. The system of any one of the foregoing claims, further comprising a shielding assembly providing a barrier to radioactive radiation, wherein the radioisotope generator is contained in the shielding assembly.
23. The system of any one of the foregoing claims, further comprising:

an eluant reservoir containing the eluant;
a pump coupled to the eluant reservoir via an eluant line;
a waste container; and
a plurality of tubing lines including an infusion tubing line, an eluate line, and a waste line, wherein the infusion tubing line is in selective fluid communication with the eluate line and the waste line is in selective fluid communication with the eluate line,

wherein the radioactivity detector is positioned to measure the radioactivity from the radioactive eluate flowing through the eluate line, and

the controller is further configured to determine a remaining capacity of the radioisotope generator before breakthrough based on the determined characteristic of the radioactivity profile indicative of breakthrough.

24. The system of claim 23, wherein the controller is configured to control the pump to pump the eluant through the radioisotope generator, thereby producing the radioactive eluate.

25. The system of claim 23, wherein:

the controller is communicatively coupled to one or more valves and configured to control a flow from the eluate line to a select one of the infusion tubing line and the waste line via the one or more valves; and

the controller is further configured to:

control the pump to pump the eluant through the radioisotope generator and generate the radioactive eluate,

determine the radioactive activity of the radioactive eluate based on radioactivity emissions measured via the radioactivity detector while the radioactive eluate is directed to the waste container,

upon the radioactive activity of the radioactive eluate reaching a threshold level of, control the one or more valves to place the infusion tubing line in fluid communication with the eluate line,

further control the pump to cause eluate to flow through the infusion tubing line,

control the radioactivity detector to continue measuring the radioactivity of the radioactive eluate while the radioactive eluate flows through the infusion tubing line.

26. The system of any one of the foregoing claims, wherein the radioisotope generator comprises one of a $^{99}\text{Mo}/^{99\text{m}}\text{Tc}$ generator, a $^{68}\text{Ge}/^{68}\text{Ga}$ generator, and a $^{82}\text{Sr}/^{82}\text{Rb}$ generator.
27. The system of any one of the foregoing claims, wherein the radioisotope generator is a $^{82}\text{Sr}/^{82}\text{Rb}$ generator.
28. The system of any one of the foregoing claims, wherein the radioisotope generator comprises a generator column loaded with the parent radioisotope.
29. The system of any one of the foregoing claims, wherein the eluant comprises an aqueous sodium chloride.