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Secretion by bacterial flagella

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Abstract

Protein virulence factors can be secreted from bacterial cells using the machinery used to assemble the flagellum.

Significance and context

Bacteria possess at least four mechanisms (types I-IV) for the extracellular secretion of proteins. The type III secretion system (TTSS) secretes proteins (sometimes termed effectors) that are usually involved in interactions of plant and animal bacterial pathogens with their hosts, and is itself composed of proteins that are conserved between the various pathogenic bacteria. Surprisingly, homology was also recently demonstrated between effectors of plant and animal pathogens, suggesting they employ similar virulence strategies; and in some cases the TTSS of a particular bacterium can secrete effectors from another. The flagellum (the organelle responsible for motion in many bacteria) possesses an extracellular filament composed of protein subunits that are exported from the cytoplasm to the cell surface. This export occurs via the 'flagellum-specific' export apparatus, which was identified as a TTSS only by homology. Despite the similarity between the two export systems, it was previously thought that the flagellum export system was responsible solely for proteins involved in filament biogenesis. The results of this paper show that the 'flagellum-specific' export apparatus is capable of transporting other proteins into the extracellular milieu. One of these exported proteins was identified as a virulence-associated phospholipase.

Key results

The proteins in culture supernatants of wild-type *Yersinia enterocolitica* were compared with those from a variety of mutants defective in flagellum synthesis. A number of proteins were found to be missing from the supernatants of the flagellar mutants. Overexpressing the master regulatory genes for flagellum synthesis resulted in overexpression of these secreted proteins in the culture supernatants. The proteins were termed Fops (flagellar outer proteins). The Fops were still secreted from a *Yersinia* strain cured of (lacking) its virulence plasmid, and thus lacking the virulence-plasmid-encoded TTSS usually associated with pathogenesis. Fop secretion was shown to be dependent on the presence of a flagellar TTSS. The authors point out that some of the Fops are likely to be components of the flagellum. The number of Fops (more than 14), however, is greater than the number of known extracellular components

(6-9) of the flagellum. Thus, it is possible that some of the Fops have functions that are not related to motility. One of the Fops was identified as being YplA, a virulence-associated phospholipase. A mutation was constructed in *yplA* and the motility pattern of mutant cells was indistinguishable from that of the wild type. Thus, YplA is not a functional component of the flagellum.

Conclusions

The demonstration that the flagellar export apparatus can also function as a protein secretion system will open new areas of research in interactions between bacteria and their hosts. Many pathogenic bacteria possessing a TTSS are also known to be motile and so a re-examination of extracellular proteins using flagellar mutants may reveal new virulence factors. Furthermore, as the authors note, the study of flagellum biosynthesis is highly developed, and a vast array of biochemical and genetic tools are available that could be used to investigate the dual function of protein secretion.

Reporter's comments

It would have been interesting to know whether 'traditional' virulence effectors could be exported through the flagellum export apparatus when the *vir* plasmid was present but the TTSS on it was knocked out. Such experiments would also raise questions about the signals required for export through the two systems, especially if each system secreted only a discreet set of effectors. The identity of the other Fops remains to be elucidated. Those not involved in flagellum synthesis could be important for bacterial virulence. The identification of YplA as a Fop, and the fact that expression of *yplA* is within a flagellar transcriptional regulon, raises the fascinating possibility that YplA was once involved in flagellum biosynthesis but has since been co-opted for a role in virulence.

Table of links

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References

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